Essential Science 5

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BOOK 5

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Author's note

We are living in an age of scientific discovery and achievement. To a large extent, our way of life is governed by machines and technical processes. Therefore, it is very desirable that, when youngsters leave school, they should possess that kind of scientific knowledge which will enable them to understand and appreciate the work of the scientist and its many everyday applications.

The books in this series provide a course in general science for children in secondary schools. Every effort has been made to ensure that the contents are interesting and attractive and truly relevant to the needs of the pupil. The illustrations are bold and colourful. The language used is simple and direct.

The practical work is straightforward and homely and can be performed with the simplest apparatus. This means that the books could be particularly useful in those schools where laboratory facilities are not available.

The written-work is at a minimum and consists of word lists, completing sentences, labelling drawings, brief descriptions, etc. It is felt that the traditional technique for writing-up experiments – apparatus, method, results and conclusions –, while suitable for pupils who are pursuing academic courses, is not suitable for the pupils for whom these books are intended.

Thanks are due to Mrs. L. Allen for her help and John Murray (Publishers) Ltd. for permission to mention their *Guide to Dissection* by H. G. G. Rowett.

C. WINDRIDGE

Important notice

This book, as with the other books in the series, has been fully "metricated and decimalized" in accordance with the Standard International System of Units (Le Système International d'Unités), known, more simply, as SI, which has been adopted as the national measuring system in the United Kingdom.

Due consideration has been given to the recommendations of the British standards authorities – the British Standards Institution, the Royal Society, the Association for Science Education, the Royal Institute of Chemistry, etc.

Some of the many SI fundamental, derived and supplementary units are:

physical quantity	*unit*	*symbol*
length	metre	m
mass	kilogramme	kg
time	second	s
temperature (customary)	degree Celsius	°C
electric current	ampere	A
area	square metre	m^2
volume	cubic metre	m^3

Further information about SI units can be obtained from these publications:

Changing to the Metric System. Her Majesty's Stationery Office.
Metrication in Secondary Education. The Royal Society.
The International System (SI) Units. The British Standards Institution, Sales Branch, 101 Pentonville Road, London, N.1.
Physio-Chemical Quantities and Units. The Royal Institute of Chemistry.
SI Units, Signs, Symbols and Abbreviations. The Association for Science Education.

Contents

1 A nature calendar

Making a nature calendar

Make a *nature calendar*.

To do this, fold a large sheet of white paper to make 12 panels. Print the name of a month at the top of each panel. In the panels, make short notes and simple drawings about the things that can be seen during each month of the year.

Paste the completed calendar into your notebook.

September

In Great Britain, September is usually a fine month. On most days in this month, the weather is warm and dry, and so farmers can finish their work on the harvest. The last of the corn crops are gathered in. Potatoes are dug up and stored away for use during the winter and the following spring.

There are many fruits on the trees and in the hedgerows.

In September, swallows, swifts and other birds migrate to the warm lands.

The autumn season begins in September. The weather becomes colder during autumn. The days become shorter and the nights become longer.

Now, you would have no difficulty with filling in the September panel on your nature calendar. But, as an example, this panel has been done for you. It is shown opposite.

The months and the seasons

The wheel-shaped picture opposite shows the months and the seasons. Look at it very carefully. Now, answer these questions. 1. What are the names of the seasons? 2. Which months are the warmest? 3. Which months are the coldest? 4. What kind of weather do you expect to have in June? 5. What kind of weather do you expect to have on your birthday? 6. In which months are the nights the longest?

The seasons

The seasons are caused by the fact that the earth is not upright but tilted.

Look at **"The Seasons"** drawing shown on the page opposite. The earth takes one year to travel in its orbit around the sun.

When the North Pole end of the earth is tilted towards the sun, it is summer in the *northern hemisphere*. The days are long and the nights are short. Can you see why? Of course, at the same time, the South Pole end of the earth is tilted away from the sun and it is winter in the *southern hemisphere*. When it is summer in Britain, it is winter in Australia.

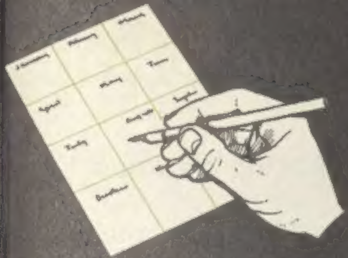
When the North Pole end of the earth is tilted away from the sun, it is winter in the northern hemisphere. The days are short and the nights are long. It is summer in the southern hemisphere.

In the middle of spring and autumn, the earth is tilted, but neither towards nor away from the sun, and so the nights are about as long as the days.

MORE THINGS TO DO

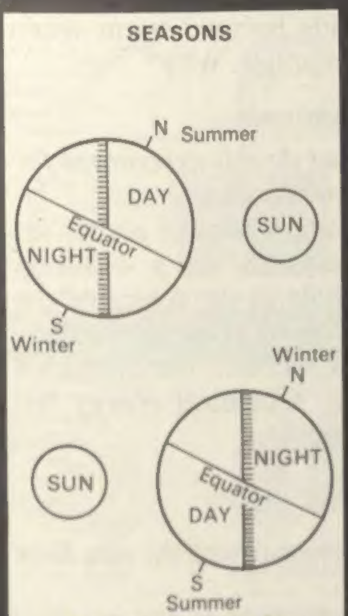
1. Copy the drawing shown in the black frame opposite. Do not draw the black frame.
2. Write a few sentences about the months and the seasons.
3. Find out the date of *Midsummer Day*.

THE MONTHS AND THE SEASONS

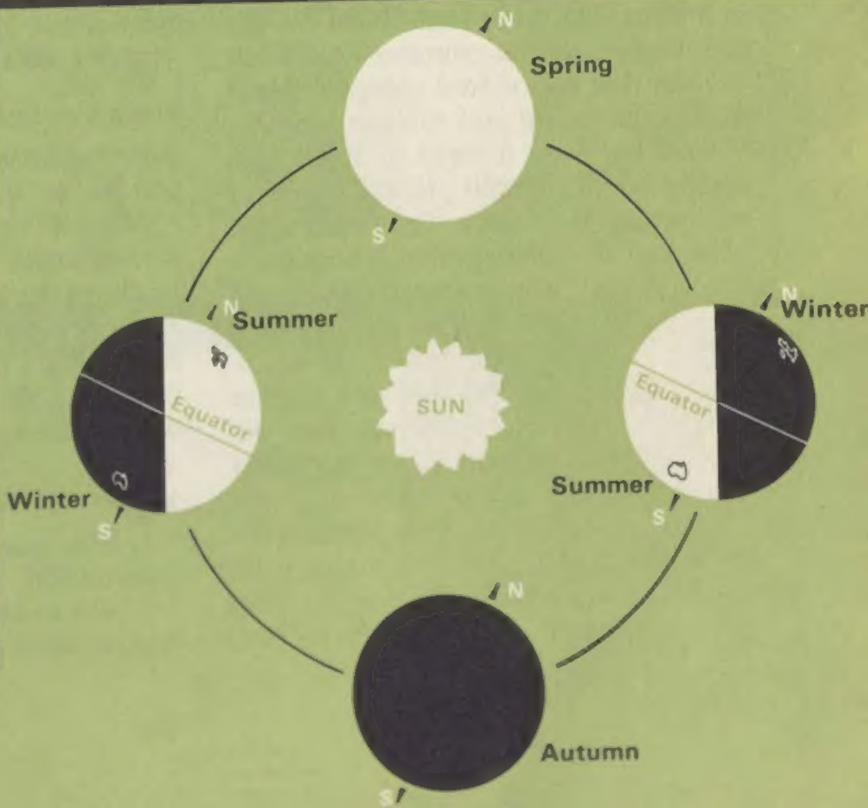


A nature calendar

THE SEASONS



A simple drawing for your notebook



2 Heat from the sun

The sun and the seasons

The days are long in the summer season and short in the winter season. Also, summer days are warm and sunny; winter days are cold and dull. It seems that we get more heat from the sun in summer than we do in winter. But, really, whatever the season, we get all our heat from the sun.

Heat from the sun

Plants trap the heat and light energy in sunshine and use it in making sugars and starches. When we eat fruit and vegetables, our bodies use the heat energy that is stored in the sugars and starches. Some animals eat plants. Some of these animals supply us with milk, fats, eggs and meat. The food that we eat during the winter months contains heat from the sun that was stored away by plants during the spring and summer months.

Coal has been formed from the vast forests which covered parts of the earth millions of years ago. The heat that is given out by burning coal is heat from the sun that was trapped and stored away by plants that were growing long before men had appeared on the earth. Coal supplies heat for the steam-engines in electricity power-stations, and so, when we use electricity, we are really using heat from the sun.

Oil has been formed from plants in the same way as coal. Paraffin, candle-wax, petrol and other fuels are obtained from oil. These fuels give us heat from the sun.

Heat is important

Heat is very important to us. We could not live without it.

In the home, heat is used for cooking, boiling water, ironing, drying clothes and warming the rooms. Light is provided by the white-hot filaments in electric lamps.

In industry, heat is used for *welding*, extracting iron from its ores, driving steam-engines, etc.

Heat is energy

But, what is heat? Heat is energy. There are other kinds of energy – movement, electricity, light and chemical energy.

One kind of energy can be changed into other kinds. An electric fire changes electricity into heat and light. The striking of a match changes movement and chemical energy into heat and light. A motor-car engine changes chemical energy, first into heat and then into movement. The end of a bicycle pump becomes warm after a few minutes of pumping; movement is changed into heat. Your hands become warm when you rub them together. Why?

Heat from chemicals

Your teacher must do this experiment for you because it could be dangerous.

Make a very small heap of *potassium permanganate* crystals on a building brick. Make a hole in the centre of the heap. Pour a drop of *glycerine* into the hole. After a few seconds, the chemicals burst into flame. Chemical energy becomes heat energy.

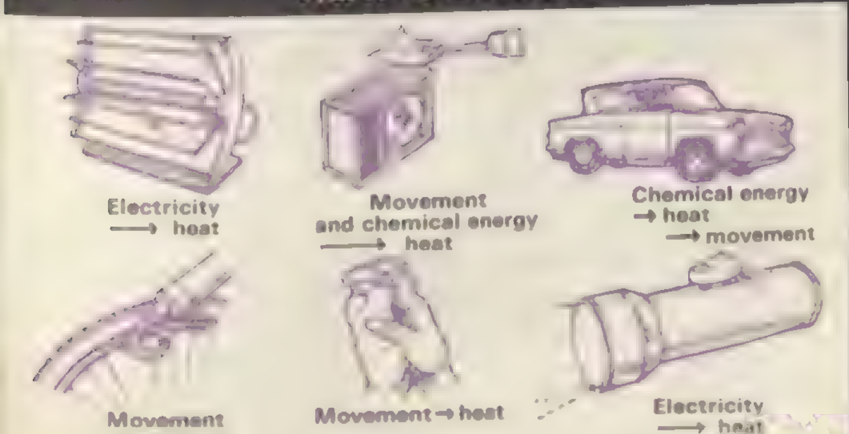
MORE THINGS TO DO

1. Write a short essay with the title *Heat from the Sun*.
2. Use an encyclopedia to find out what you can about *oil* and *welding*.

Heat from the sun

HEAT IS IMPORTANT

HEAT IS ENERGY



HEAT FROM CHEMICALS

3 The work of leaves

Leaves trap sunshine

Plants feed on the mineral salts in the soil. The mineral salts, dissolved in water, are taken in by the roots of the plants. Plants also feed on the carbon dioxide gas in the atmosphere. The carbon dioxide is taken in by their leaves.

Leaves trap light energy in sunshine and use it to make sugar from carbon dioxide and water. Then, the sugar changes into starch. Carbon dioxide enters leaves through tiny holes in their surfaces. Water enters plants through their roots and then passes up their stems into their leaves. In making starch, leaves give off oxygen which passes out of the leaves through the tiny holes on their surfaces. *Carbon dioxide + water + light energy = starch + oxygen.*

Leaves are green because they contain a green dye that is called *chlorophyll*. It is chlorophyll that enables leaves to trap light energy in sunshine. Leaves make chlorophyll only when they are exposed to sunlight. Perhaps, when you have been in a field or on a lawn, you have kicked over a stone and noticed that the grass under the stone is weakly and white or yellow. This is because the grass has not been exposed to sunlight.

Leaves contain starch

Put a leaf in water in a test-tube. Boil the water in the test-tube for a few minutes. This softens the leaf. Then, put the leaf in methylated spirit in a test-tube. The chlorophyll dissolves in the spirit. Wash the decolourised leaf with water and dip it into a weak solution of iodine in a small dish. The leaf turns blue-black in colour. Why?

Chlorophyll and starch

Repeat the previous experiment, but use a *variegated privet leaf*. A variegated leaf is one that has dark and light green patches. You notice that starch is present only in those parts of the leaf that were dark green. What does this show?

Sunlight makes chlorophyll

Use a strip of paper to cover a part of a leaf on a growing plant. Fix the paper strip in place with paper clips.

After a few days, test the leaf for starch. There is little or no starch in the part of the leaf that was covered by the paper strip. Why?

Leaves give off oxygen

Place a water plant, such as *Canadian Pondweed*, in a dish of water. Cover the plant with a funnel and a test-tube in the way shown opposite. Stand the dish in bright sunlight.

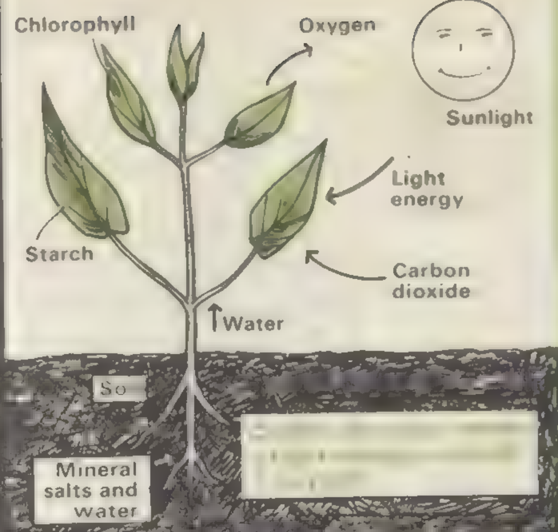
After a few hours, remove the test-tube and, immediately, put a glowing splint of wood into its mouth. The splint bursts into flames. What does this show?

MORE THINGS TO DO

1. Copy the drawing shown in the black frame opposite.
2. Draw a variegated leaf. Colour the drawing green and light green (crayon is best for this).
3. Copy this sentence.

Leaves Make Starch
Carbon dioxide + water + light energy
= starch + oxygen.

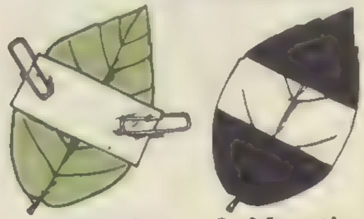
The work of leaves



CHLOROPHYLL AND STARCH

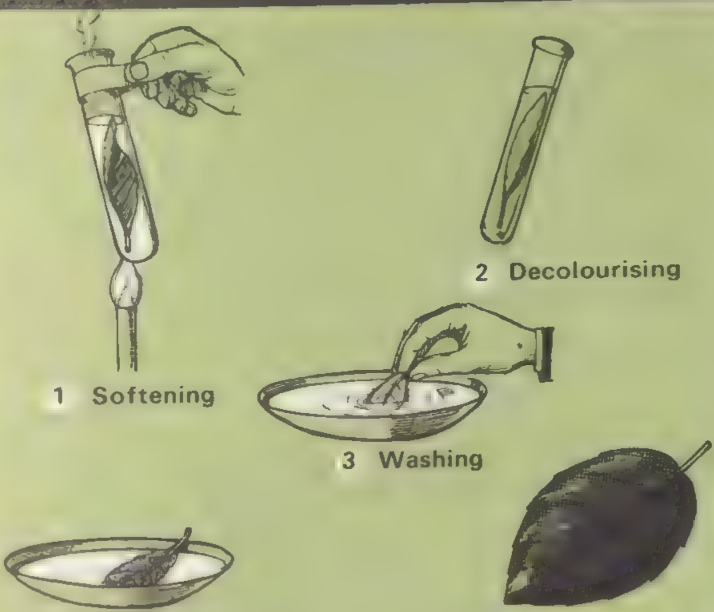
1. Variegated leaf
2. After the iodine test

SUNLIGHT MAKES CHLOROPHYLL

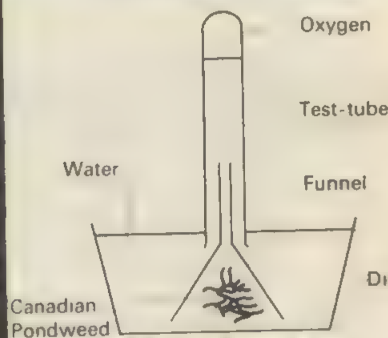


1. Leaf partly covered with a paper strip
2. After the iodine test

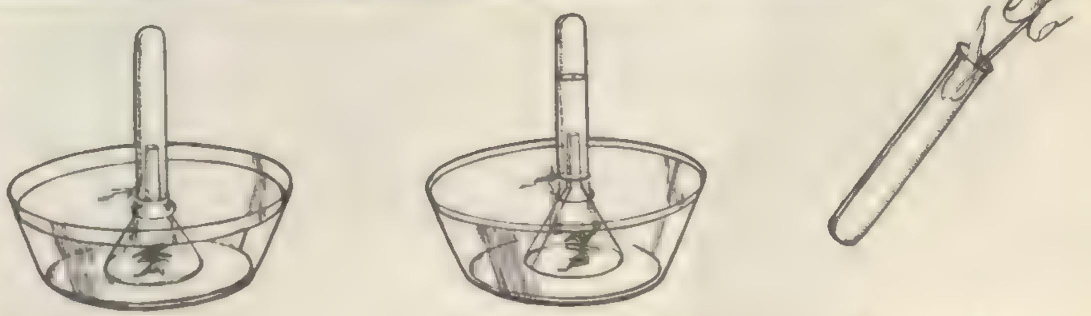
LEAVES CONTAIN STARCH



LEAVES GIVE OFF OXYGEN



LEAVES GIVE OFF OXYGEN



4 Flowering plants

The plant kingdom

As you already know, the plant kingdom can be divided into two kinds of plants – the *flowering* and the *non-flowering*.

Which of these are flowering plants?

Foxglove; mushroom; common fern; carrot; peat moss; barley; wild arum.

Flowering plants

There is much variety among flowering plants. Some are large and some are small. Some have very unusual shapes and colours. But, every flowering plant has four main parts – *roots, stems, leaves* and *flowers*.

Each part of a flowering plant has its own work to do, as this table shows.

FLOWERING PLANTS AT WORK

Roots	Hold plants in the ground so that they are neither washed nor blown away. Take in water and food (minerals). Some store food.
Stems	Stand upright or climb upwards so that the leaves can obtain the most sunlight. Carry food and water to and from the leaves and roots. Some store food.
Leaves	Breathe. *Transpire.* Make food (starch). Some store food.
Flowers	Make seeds from which new plants will grow.

Looking at a flowering plant

Examine a flowering plant, such as *shepherd's purse*. Look for the four main parts.

The work of leaves

Leaves trap energy in sunshine and make starch. This is very important work. But, as the table above shows, leaves do other important work. They breathe and transpire. "Transpire" means "give off water". Some store food. An onion bulb is made of leaves that are large and swollen because they are filled with food.

Leaves transpire

Place a leafy twig in a small jar of water. Pour a little olive oil on to the surface of the water so that none of it will be lost by evaporation. Cover the small jar with a large jar.

After a few hours, there will be tiny drops of water on the inside of the large jar. What has happened?

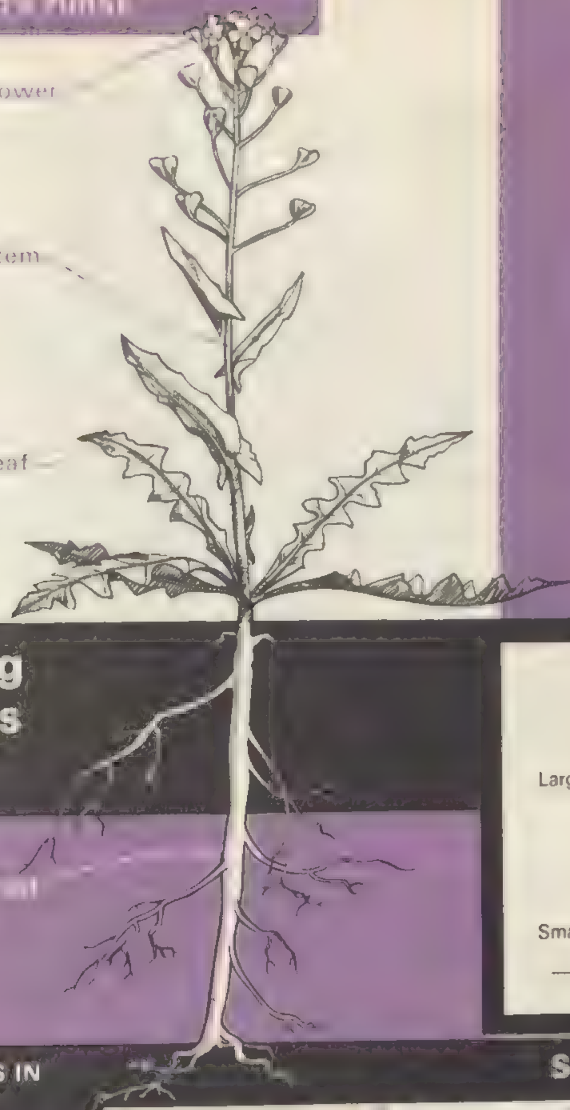
Stems

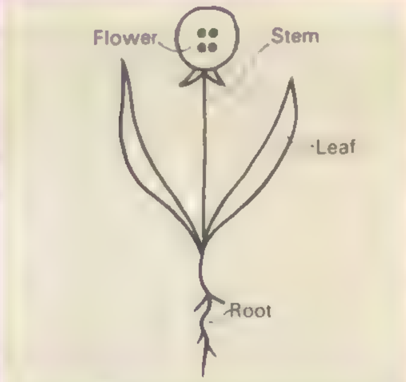
There are so many different kinds of stems. Trees have thick, woody stems. *Cactus* plants live where it is very dry; their stems are very fat so that they can store water. The leaves of cactus plants are small prickles. Some stems are thin but they support themselves and climb upwards by twining around other plants. Some climbing plants have thorns by which they attach themselves to supports. The ivy plant has small roots on its stems. These roots cling to walls and other supports. Some different kinds of stems are shown opposite.

MORE THINGS TO DO

1. Make a simple drawing of a flowering plant in the way shown opposite.
2. Copy the table which shows the work done by each part of a flowering plant.
3. Copy the drawing shown in the black frame opposite.
4. Make free-hand drawings of some of the stems shown opposite. Print their names below them.

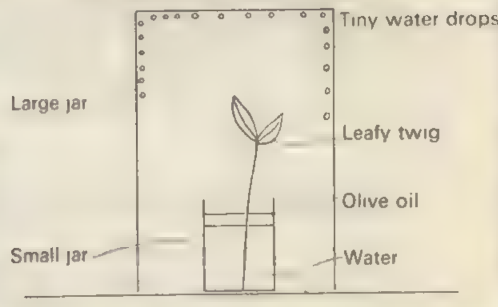
Flowering plants



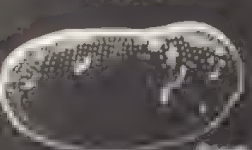


A flowering plant has four main parts

LEAVES TRANSPIRE

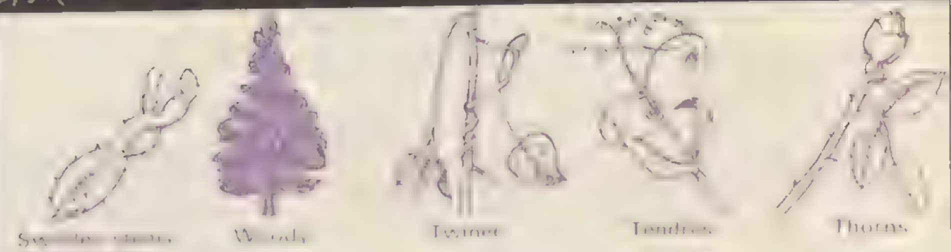


FOOD STORES IN PLANTS



Onion

STEMS



Prickly Pear Cactus

Larch

Runner Bean

Sweet Pea

Rose

5 At the gas-works

Energy from coal

Energy from the sun is stored in plants. Coal has been formed from plants that were growing on the earth millions of years ago, and so, energy from coal is really energy from the sun.

Much of the energy that we use comes from coal. Coal supplies heat energy for electricity power-stations. Coke, coal-gas and other fuels are made from coal.

The manufacture of coal-gas

The important stages in the manufacture of coal-gas are shown on the page opposite and briefly described below.

At the Gas-Works

Retort house. Coal is heated in closed retorts and coal-gas is given off. Coke is left behind in the retorts.

Condenser. Cools gas. Tar and ammonia collect.

Exhauster. Pumps gas through pipes.

De-tarrer. Takes out the remains of the tar.

Scrubber. Washes gas with water to remove ammonia.

Purifier. Takes out poisonous gases.

Benzol plant. Takes out *benzol*. Benzol is also called *benzene*.

Meter. Measures the amount of gas that is made.

Gas-holder. Stores gas.

Dryer. Removes moisture.

Governor. Keeps the gas at the same pressure.

Customers. Buy and use gas.

Paying for coal-gas

How do the customers pay for the coal-gas that they use?

Coal-gas is usually sold at so much *per therm*. A *gas-meter* measures gas in *cubic feet*. 200 cubic feet of gas provide 1 therm of heat.

Therms used = cubic feet used ÷ 200.
Cost of gas = therms used × price per therm.

No doubt, very soon, gas meters will measure gas in metric units – probably *cubic metres*.

Reading a gas-meter

Look at a gas-meter. Perhaps there is a gas-meter in your school.

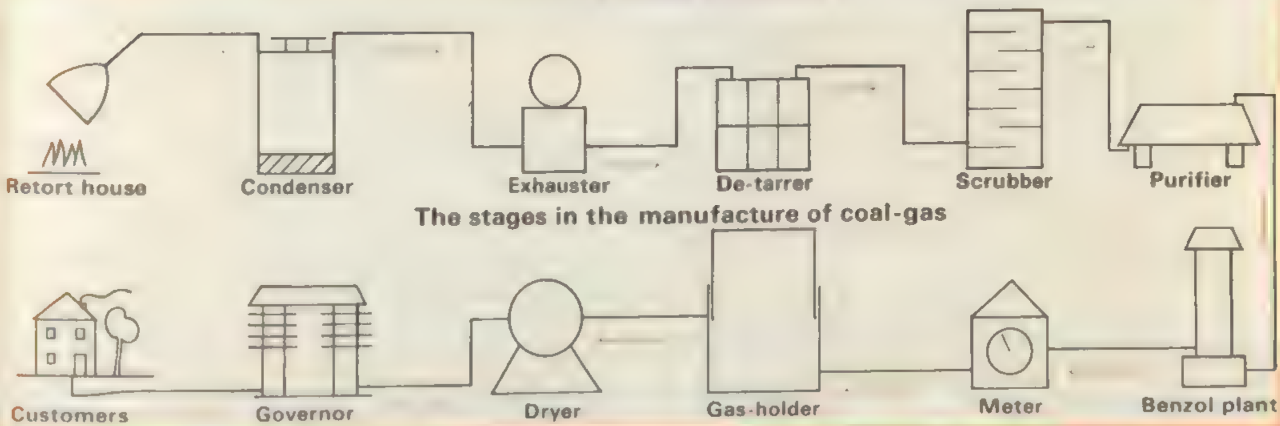
Read the dials from left to right. Do not bother about the top dial; it is used for testing purposes. A pointer must be read as showing the figure that it has last passed and not the one to which it may be nearest. Take the previous reading away from this one to find the number of cubic feet that has been used since the previous reading.

MORE THINGS TO DO

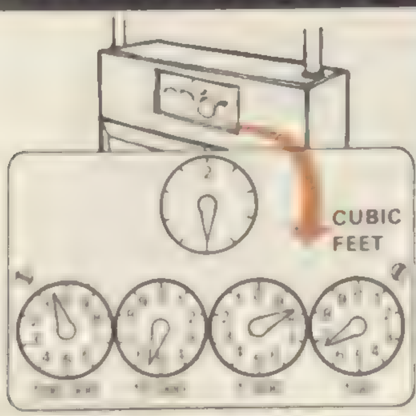
1. Copy the **"At the Gas-Works"** drawing shown opposite.
2. Copy the table above which shows the stages in the manufacture of coal-gas.
3. Look up the word "benzol" in a dictionary and find out what it means.
4. Read the gas-meter dials A, B and C shown opposite.
5. Work out the cost of using (a) 800 and (b) 20 000 cubic feet of coal-gas if the price of coal-gas is 8p per therm.
6. Visit a gas-works if you get a chance.

At the gas-works

AT THE GAS-WORKS



READING A GAS-METER



Dials show 058 600 cubic feet

6 Flames

What are flames?

Flames are burning gases. Flames are *luminous* because they contain many white-hot particles of carbon. "Luminous" means "giving out light". When there is a lack of air, some of the carbon particles do not burn and the flames are smoky. Smoke and soot are unburnt carbon particles.

Bunsen burner flames

Perhaps you have noticed that the flame of a bunsen burner has three parts.

When the air-hole is closed, the flame is luminous because there is a lack of air and the particles of carbon inside the flame become white-hot but do not burn away until they come into contact with the air on the outside of the flame. The outside of the flame is burning gas. The inside contains white-hot carbon particles. The centre is unburnt gas; it is cold.

When the air-hole is open, the flame is not luminous because the coal-gas is mixed with air and it burns away completely before white-hot carbon particles can form. The outside of the flame is burnt gas. The inside is burning gas. The centre is unburnt gas; it is cold.

Looking at a bunsen burner flame

Close the air-hole of a bunsen burner. Turn on the gas tap and light the burner. Look for the three parts of the luminous flame.

Open the air-hole. Look for the three parts of the non-luminous flame.

Now, half close the air-hole. What do you notice about the flame?

Soot from a bunsen flame

Close the air-hole of a bunsen burner. Turn on the gas tap and light the burner. Hold a plate over the flame for a short time. What is the black substance that collects on the plate?

The cold centre of a bunsen flame

1. Push a pin through a match just below its head. Do not push the pin into the head of the match. Why?

Use the pin to support the match inside the top of a bunsen burner chimney. Turn on the gas and light it. The flame burns for a long time before the match-head ignites. Why?

2. Hold a piece of white paper over a bunsen burner flame for a very short time. A charred ring is made. Why?

A candle flame

A candle flame has four parts. The outside is burning gas. The inside contains white-hot particles. The centre is unburnt gas. At the bottom, there is a part that is very hot.

The unburnt part of a flame

Use tongs to hold the end of a glass or metal tube in the centre of a candle flame. Light the gas which comes out of the other end of the tube.

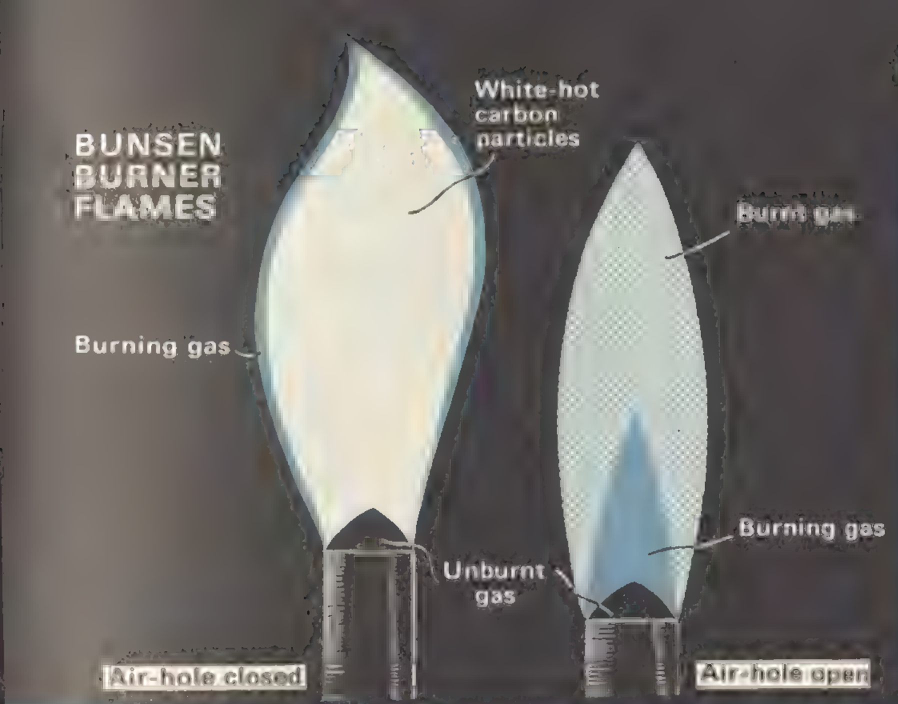
Now, do the same with a bunsen burner flame.

What do these two experiments show?

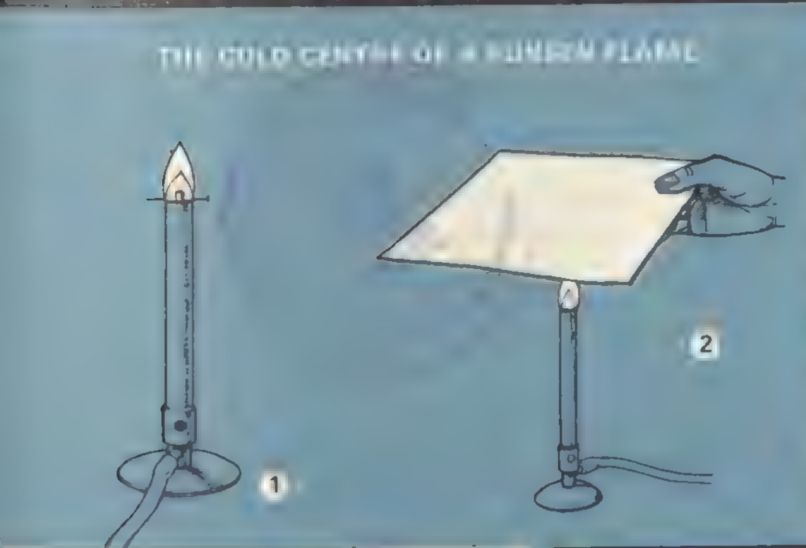
MORE THINGS TO DO

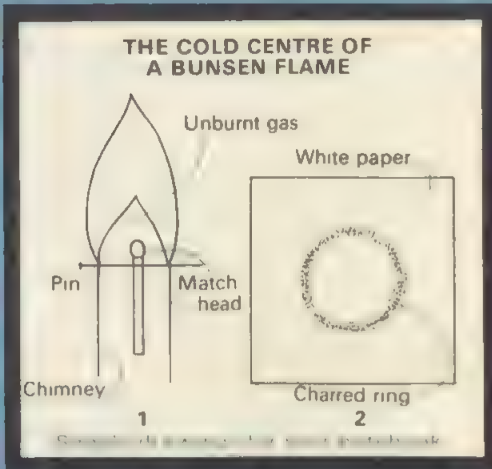
1. Draw a candle flame. Label each part.
2. Copy the drawings shown in the black frames opposite.

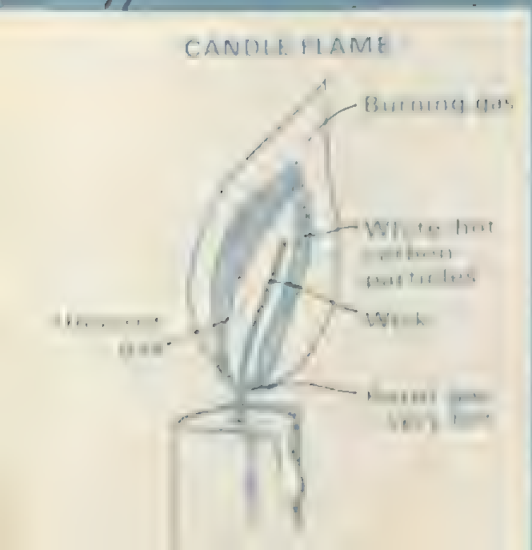
Flames

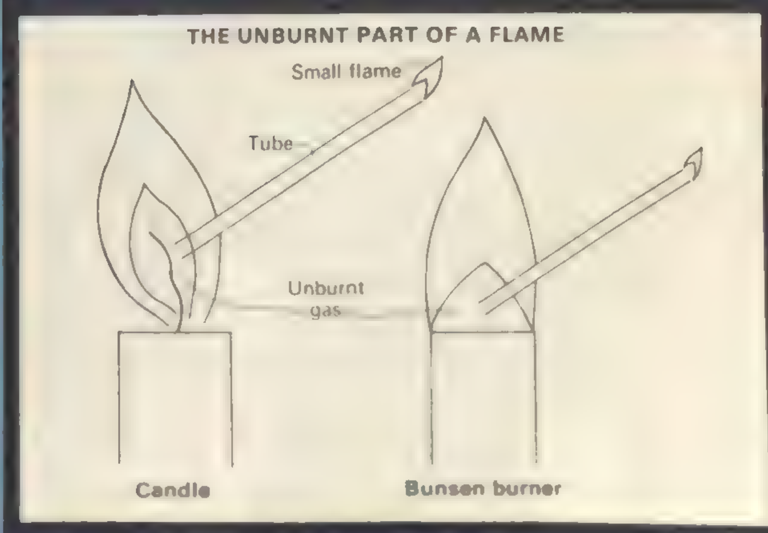

BUNSEN BURNER FLAMES
White-hot carbon particles
Burnt gas
Burning gas
Burning gas
Unburnt gas
Air-hole closed
Air-hole open


SOOT FROM A BUNSEN FLAME


1
2


THE COLD CENTRE OF A BUNSEN FLAME
Unburnt gas
White paper
Pin
Match head
Chimney
Charred ring
1
2


CANDLE FLAME
Burning gas
White-hot carbon particles
Wick


THE UNBURNT PART OF A FLAME
Small flame
Tube
Unburnt gas
Candle
Bunsen burner

7 The diesel engine

The diesel engine

Omnibuses, heavy lorries, motor ships, submarines and railway locomotives are powered by diesel engines.

The *diesel engine* was invented about 70 years ago. It is named after its inventor, Rudolph Diesel, a German engineer.

The diesel engine works in much the same way as the petrol engine, but, instead of petrol, it burns oil. Oil is less expensive than petrol. The diesel engine needs no sparking-plugs. The oil is ignited by hot air in the cylinders.

How the diesel engine works

The diesel engine works by the explosion of a mixture of air and oil vapour inside a cylinder. The hot, expanding gases push a piston. The piston moves and, in so doing, turns a *crankshaft*.

There are five stages in the movement of the piston up and down a cylinder in a diesel engine. They are *suction, compression, injection, ignition* and *exhaust*.

The five stages are shown opposite.

This is what happens at each stage.

1. *Suction*. The *inlet valve* opens and the piston falls. Air is sucked into the cylinder.

2. *Compression*. The inlet valve closes and the piston rises. The air is compressed and becomes very hot. It reaches a temperature of about 700°C.

3. *Injection*. A nozzle sprays oil into the hot air in the cylinder. The oil forms a fine mist.

4. *Ignition*. The hot air ignites the oil. It burns rapidly. The hot, expanding gases push the piston downwards.

5. *Exhaust*. The *exhaust valve* opens and the piston rises. The waste gases are pushed out of the cylinder.

The valves are made to open and close at the right times by *cam-wheels* on the crankshaft.

The five stages can be easily remembered as "*suck, squeeze, squirt, bang* and *blow*".

Heat by compression

Use a bicycle pump to blow up a football very quickly. Of course, you will need an *adaptor* for this.

Feel the bottom end of the pump. It is warm because air becomes hot when it is compressed.

A model diesel engine

Examine and operate a small diesel engine of the kind used to power model aeroplanes, if one is available. Follow the maker's instructions. Perhaps your teacher will help you with this.

MORE THINGS TO DO

1. Copy the simple drawing of a diesel engine shown opposite.

2. Copy these sentences, filling each space with a suitable word.

The Diesel Engine

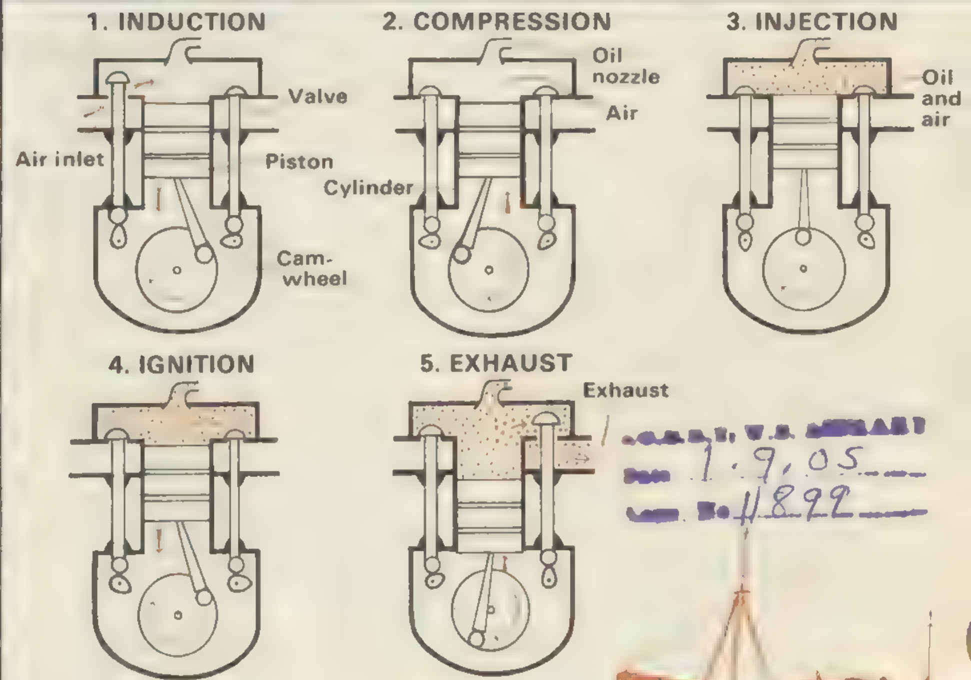
The five stages in the movement of a diesel engine piston are suction, compression, injection, ignition and ....

These stages can easily be remembered as "suck, squeeze, ..., bang and blow".

The diesel engine needs no sparking-plugs and burns ....

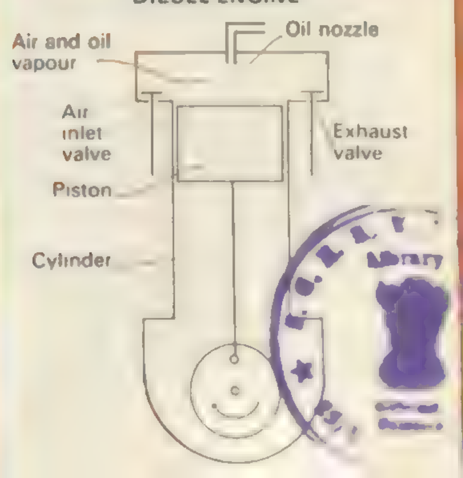
3. Find out why you must use an adaptor when you are blowing up a football with a bicycle pump.

The diesel engine



HEAT BY COMPRESSION

SIMPLE DRAWING OF A DIESEL ENGINE



8 A bicycle pump

Inflating bicycle tyres

In the **"Heat by Compression"** experiment in Chapter 7, you inflated a football with a bicycle pump. "Inflated" means "blew up". Of course, a bicycle pump is really intended for inflating bicycle tyres.

The force of compressed air

Place a large book on a paper bag. Use your mouth to blow into the bag. The book lifts. Why?

How a bicycle pump works

A bicycle pump is a long cylinder with a *piston*. The piston is a long, thin, metal rod. It is free to move up and down the inside of the cylinder. At one end of the piston rod, there is a handle. At the other end, there is a leather washer. This washer is a *valve*.

When the handle is pushed forward, the piston moves down the cylinder and compresses the air inside it. The compressed air flattens the washer against the sides of the cylinder. The washer forces the air out of the end of the pump.

When the handle is pulled back, the piston moves up the cylinder. Air pressure pushes the washer back into its original shape and air fills the cylinder.

The parts of a bicycle pump

Unscrew the cover on the top of a bicycle pump and take out the piston.

Examine the parts of the pump – piston rod, washer, *cylinder spring* and *handle spring*. What are the purposes of the springs?

Take out the *connector* that is kept in the handle. What is the purpose of the connector?

Now, put the parts together and screw the cover back into place.

Using a bicycle pump

1. Hold one of your fingers near the bottom end of a bicycle pump. Push the handle up and down several times. What do you feel?

2. Plug the open end of the pump with plasticine. Push the handle forward quickly. The plasticine is blown out of the pump and there is a "pop". What causes the "pop"?

3. Unscrew the cover on the top of the pump and take out the piston. Change the washer round. Replace the piston. Hold one of your fingers near the bottom end of the pump. Push the handle up and down several times. What do you feel? The pump now sucks in air. It does not blow out air.

Other pumps

Besides the bicycle pump, there are other kinds of pumps. Some pump gases and some pump liquids. Two common kinds are the *lift pump* and the *force pump*. They are used for lifting water.

A force pump will send a jet of water to a great height. The height of the jet depends on the force on the piston of the pump. Fire-engine pumps are force pumps.

Opposite, there are drawings that show how these pumps work.

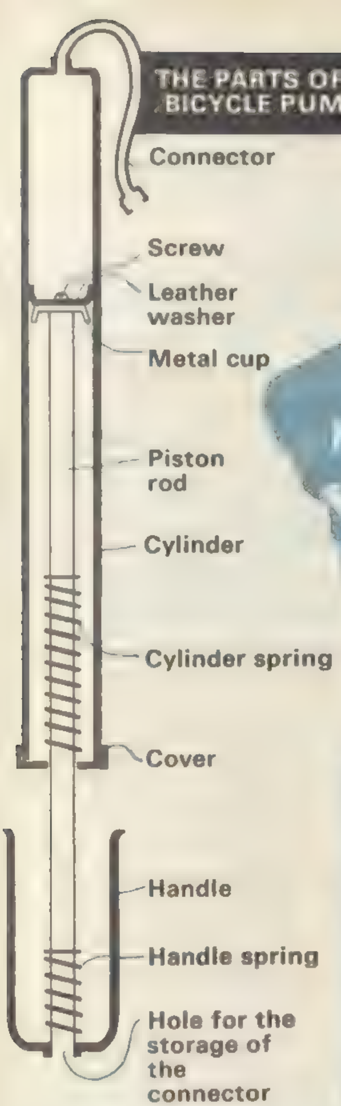
MORE THINGS TO DO

1. Draw the parts of a bicycle pump. Label each part.

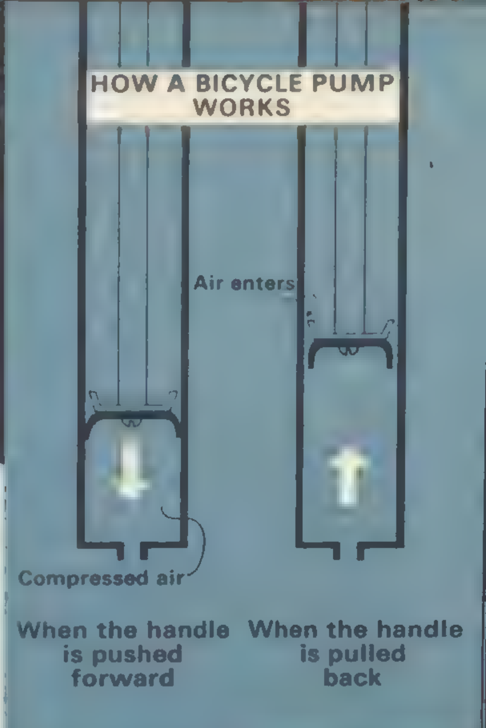
2. Copy the drawings of *either* the lift pump *or* the force pump shown opposite. Below the drawings, write a few sentences to explain how the pump works.

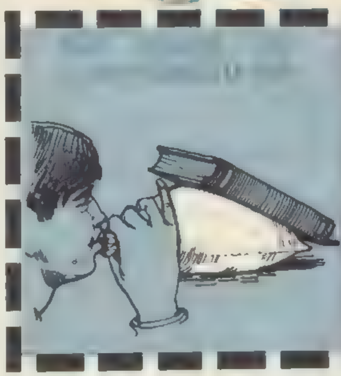
A bicycle pump

THE PARTS OF A BICYCLE PUMP

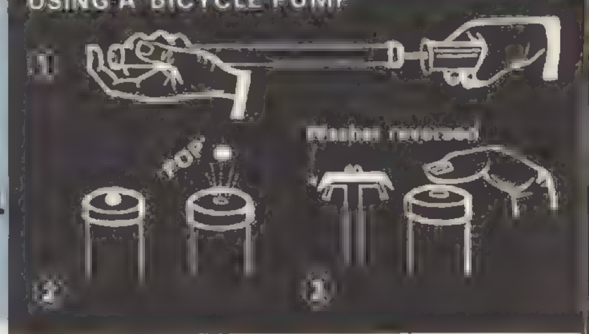


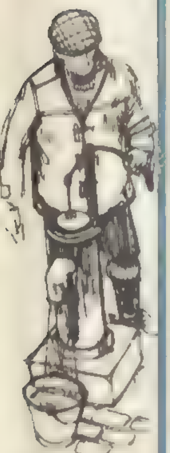
HOW A BICYCLE PUMP WORKS



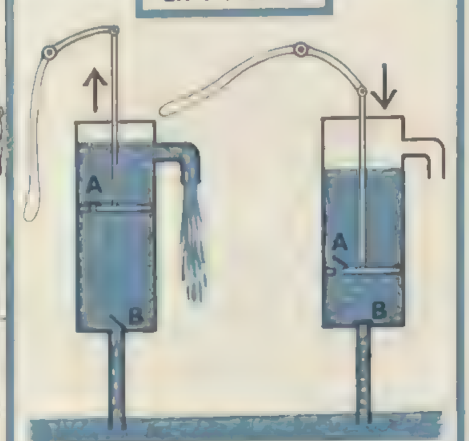


USING A BICYCLE PUMP





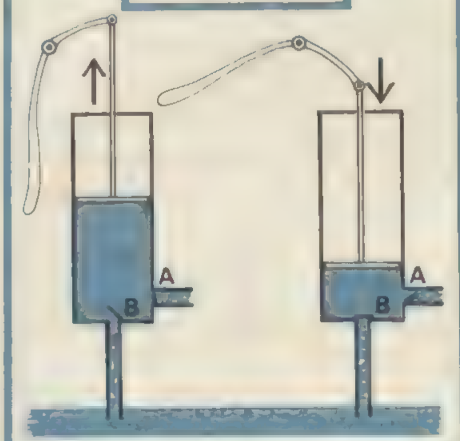
LIFT PUMP



When the piston is raised, the weight of water above it keeps valve A closed. The rising piston lifts water into the outlet pipe. Air pressure forces water up the inlet pipe through the open valve B into the cylinder.

When the piston is lowered the water below the piston closes valve B and opens valve A so that water fills the cylinder.

FORCE PUMP



When the piston is raised, valve A closes and valve B opens. Air pressure forces water up the inlet pipe into the cylinder.

When the piston is lowered, the water in the cylinder closes valve B and opens valve A. Water is forced into the outlet pipe.

9 Energy and work

Energy

You know that there is more than one kind of energy. Also, you know that one kind can be changed into other kinds. An electric fire changes electrical energy into heat and light energy.

But, what is energy? When a man works, he uses the chemical energy stored in the food that he has eaten. Steam, petrol and diesel engines do work for us; they use the energy stored in fuels. And so, we can say that *energy is something that does work*.

Kinetic energy

The energy of something that is moving is called *kinetic energy*. "Kinetic" means "movement". Rolling marbles, running water, motor-cars speeding along the road, swinging clock pendulums and rotating fans are all in movement. Their movements are kinetic energy.

Potential energy

Stored energy is called *potential energy*. Food, coal, petrol, electric batteries, coiled watch springs, water at a height and gunpowder have potential energy.

When potential energy is released, it becomes kinetic energy. A steam-engine changes the potential energy in coal into kinetic energy. As a watch spring uncoils, its potential energy becomes kinetic energy. Potential energy becomes kinetic energy when turbines are turned by the water stored behind a dam.

A water-jet turbine

Make a water-jet turbine.

Use a hammer and a nail to punch small holes around the bottom of a metal can. Hold the nail at an angle in the way shown opposite. Punch two holes in opposite sides of the top of the can. Tie the ends of a string to these two holes. Hold the string with one of your hands. Fill the can with water. Jets of water spurt from the holes in the bottom of the can. The can turns. The potential energy of the water in the can becomes kinetic energy.

Work

When a person digs a garden, pushes a wheelbarrow or writes a long and difficult letter, we say that he is at work. But, for scientists and engineers, the word *work* has a more exact meaning than this. Work is done when an object moves. An object is made to move by a *force*. A force is a *push* or a *pull*.

Work = force × distance through which the force moves.

Engineers measure force in *kilogrammes* (kg), distance in *metres* (m) and work in *kilogramme-metres* (kg m) A force of 10 kg is needed to lift a bucket of water that weighs 10 kg. If the bucket is raised 4 m, the work done = 10 kg × 4 m = 40 kg m.

MORE THINGS TO DO

1. Write one sentence about each of these words in a way which shows that you know what the word means.

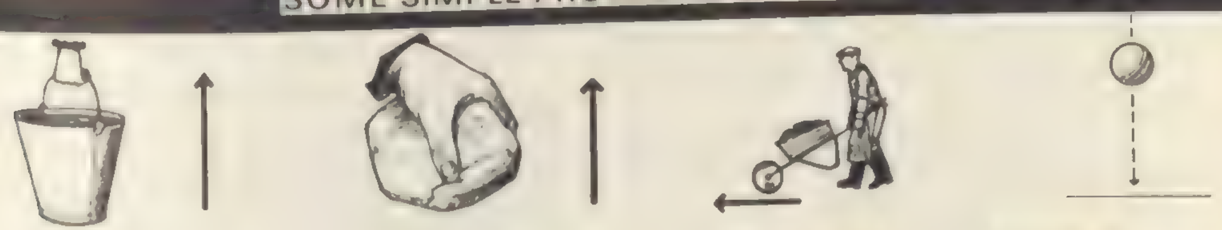
   Energy; kinetic; potential; force; work.

2. Make a free-hand drawing of a water-jet turbine.

3. Do the simple problems on work that are shown opposite.

Energy and work

SOME SIMPLE PROBLEMS ON WORK



How much work is done?

What is the weight of the stone?

How much work is done?

How far does the ball fall?

10 Movement and speed

Movement and force

Objects do not move of their own accord. A force is needed to start or stop the movement of an object.

When a footballer kicks a ball, the force from his foot starts the ball moving. When he catches the ball, the force from his hands stops the movement of the ball.

If you hold a ball in your hand and then release it, it falls straight to the ground. It is made to move downwards by the force of the earth's gravity. If there were no force of gravity, the ball would remain suspended in mid air.

A rolling marble slows down and then comes to rest. Its movement is stopped by the forces of friction and air resistance. But for these forces, the marble would carry on rolling.

Inertia

A large force is needed to start or stop the movement of a heavy object, but only a small force is needed to start or stop the movement of an object that is light in weight. The resistance of an object to a force acting on it is called its *inertia*.

A person standing in a bus moves forward quickly when the bus stops suddenly. His inertia carries him forward. He moves backwards when the bus starts suddenly. Some other examples of inertia are shown opposite.

Some inertia tricks

1. Place a postcard on the top of a glass tumbler. Then, put a penny on the card. Flick the card quickly. It flies off the top of the tumbler. The penny remains where it is because of its inertia, and then it falls into the tumbler.

2. Place a penny on a match-box. Push the match-box quickly against an obstacle, such as a block of wood. The box comes to a sudden stop, but the penny jumps forward. Why?

3. Spin two eggs, one raw and the other hard-boiled, on a smooth table. Place your fingers on the eggs for a moment. When you remove your fingers, the hard-boiled egg remains still but the raw egg begins to turn slowly. The liquid inside the raw egg has continued to spin because of its inertia, and so, when you remove your fingers, the shell is pulled around with the liquid.

Speed

The *speed* of a moving object is the distance that it travels in a certain time. If a rolling marble travels 2 metres in 1 second, its speed is 2 *metres per second*. If a motor-car travels 40 kilometres in 1 hour, its speed is 40 *kilometres per hour*, which is written, for short, as 40 *km/h*. How far does a car travel in 3 hours if its speed is 50 km/h.

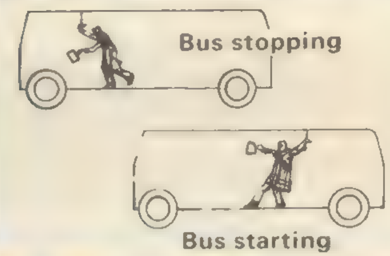
MORE THINGS TO DO

1. Write a few sentences about movement and force.
2. Write a few sentences about inertia.
3. Do the simple problems on speed that are shown opposite.
4. Find out what this statement means. "When a dog is wet, it shakes its body quickly and so dries its coat by inertia."

A force is needed to start or stop the movement of an object

Movement and speed

INERTIA



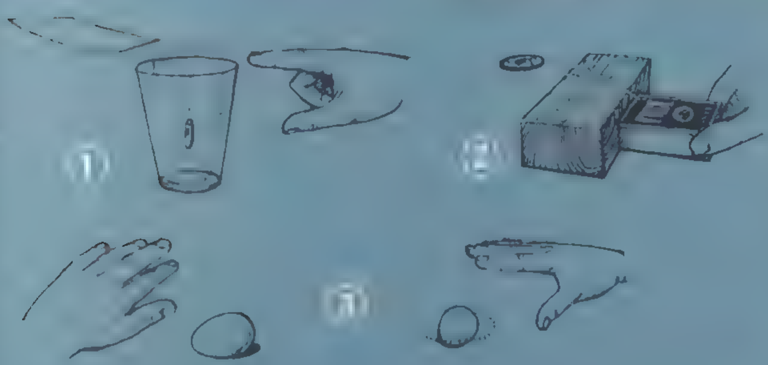
A locomotive uses a large force to start a train, but, once the train has started, the locomotive uses only a small force; the inertia of a train keeps it moving.

The passengers are thrown sideways when a car turns.

The handle stops moving. The head, because of its inertia, carries on moving and becomes tightly wedged on the handle

Tightening a hammer head

SOME INERTIA TRICKS



SOME SIMPLE PROBLEMS ON SPEED

A toy train travels 45 metres in 15 seconds

A cyclist travels 6 kilometres in 30 minutes

A car moving at a speed of 60 km h. takes 2 hours to travel from town A to town B.

The distance between London and Glasgow is about 560 kilometres An aeroplane flies from Glasgow to London at a speed of 1 120 km h

11 Some helpful wheels

Movement and wheels

Many machines contain wheels. The wheels reduce friction and so make movement easier. Why is it easier to pull a wheeled truck than a sledge?

Two very helpful kinds of wheels are *pulleys* and *gear-wheels*.

Pulleys

Pulleys are wheels that carry moving ropes and chains. The pulleys turn with ropes and chains; this reduces friction.

On the page opposite, you can see a boy lifting a heavy bucket in three different ways. It is difficult for him to lift the bucket with his hands. It is less difficult for him to lift the bucket with a rope that passes over a wooden beam because it is easier for him to pull downwards than to pull upwards; the weight of his body helps him to pull on the rope. But, after a time, the rope is worn away by friction; then, the rope breaks. The best way for him to lift the bucket is with a rope that passes over a pulley. The pulley turns with the moving rope and so there is very little friction.

Using more than one pulley

By using more than one pulley, it is possible to lift a large load with a small force. But, you will understand this better if you make a model *pulley system*.

A model pulley system

Make a model pulley system in the way shown opposite.

Pull the string. How far does your hand move? How far is the can of pebbles lifted?

What force is shown by the spring balance? Now, remove the spring balance and use it to weigh the can. What is its weight? How many times is the load bigger than the force?

Using pulleys

Pulleys are used in lifting machines, such as the *crane*, the *endless chain* and the *block and tackle*. The endless chain and the block and tackle are used by builders. A small force lifts a heavy load.

Gear-wheels

Gear-wheels are used for changing speeds. When two gear-wheels are brought into contact with each other, one can be made to drive the other. A large gear-wheel turning slowly causes a small gear-wheel to turn quickly; a small gear-wheel turning quickly causes a large gear-wheel to turn slowly.

Gear-wheels have teeth, called *cogs*, by which they grip each other very tightly.

Model gear-wheels

Make some model gear-wheels in the way shown opposite.

Turn the smaller wheel with your hand. Does the larger wheel turn faster or slower than the smaller wheel?

Using an egg-whisk

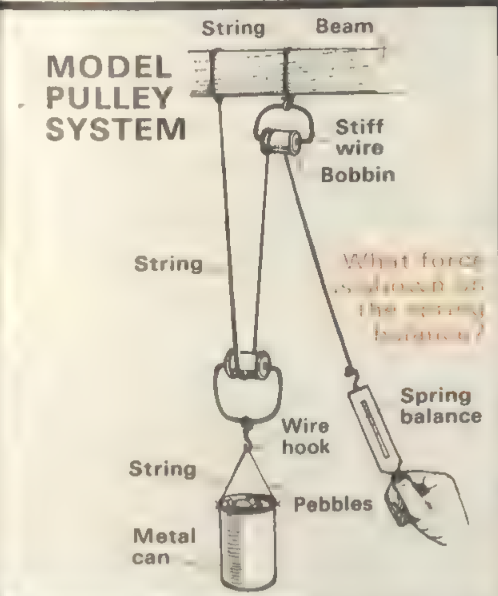
Turn the handle of an egg-whisk. Why does the whisk spin quickly?

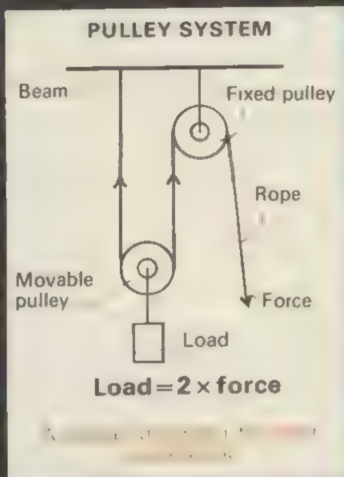
MORE THINGS TO DO

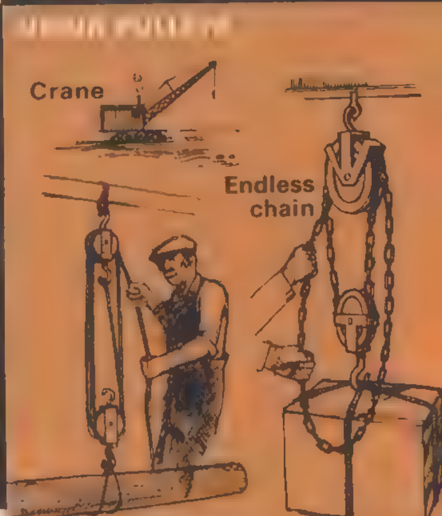
1. Copy the drawing shown in the black frame opposite.
2. Draw an egg-whisk.

Why is it easier to pull a wheeled truck than a sledge?

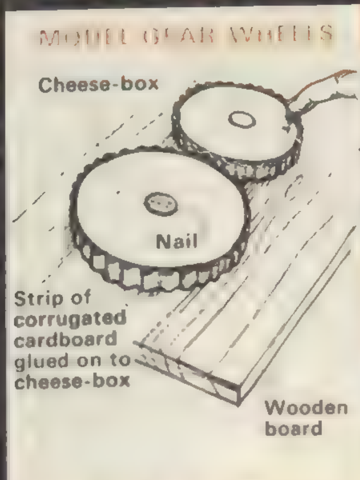
Some helpful wheels







Block and tackle



12 Colours

White light

Sometimes, after a rain shower, a rainbow is seen because raindrops split up the colours in the sunlight. Sunlight is *white light*, and white light is a mixture of 7 colours – *red, orange, yellow, green, blue, indigo* and *violet*.

Colours

The colour of a surface depends on the coloured light that it reflects. When white light falls on a banana, its skin *absorbs* all the colours except yellow. The yellow light is reflected back into your eyes. A coloured surface may not have the same colour in coloured light that it has in white light. A green surface looks black in red light. The red light is absorbed and there is no green light to be reflected. Perhaps you have noticed the strange colours of things that are illuminated by the orange-yellow light from *sodium-vapour lamps*.

Black and white

Black and white are not colours. Black is the complete absence of colours. If a surface absorbs nearly all the light that falls on it, the surface is black.

Transparent materials

A coloured *transparent* material, such as red or green glass, allows only light of the same colour to pass through it.

Colour mixing

Red, green and *blue* are called the *primary colours*. Light of any colour can be obtained by mixing two or three of these primary colours in the right amounts.

A mixture of two primary colours is called a *secondary colour*. A mixture of red and green light gives yellow light. Yellow is a secondary colour.

Experiments with colours

Cover the heads of three torches with coloured cellophane paper – one red, one blue and one green.

Shine the three torches together on to a sheet of white paper in a darkened room. The paper is nearly white where the three colours overlap. The colours in the cellophane may not be pure. Therefore, adjust the distances of the torches so that you get a purer white.

Now, try making secondary colours. Red and green give yellow; red and blue give crimson, blue and green give turquoise.

Shine the torches, in turn, on pieces of black, white and coloured wool. Can you explain the apparent colours of the wools?

Colour-blindness

If a person confuses one colour with another, he is said to be *colour-blind*. In one common kind of colour-blindness, a person is not able to tell the difference between green, yellow and orange.

MORE THINGS TO DO

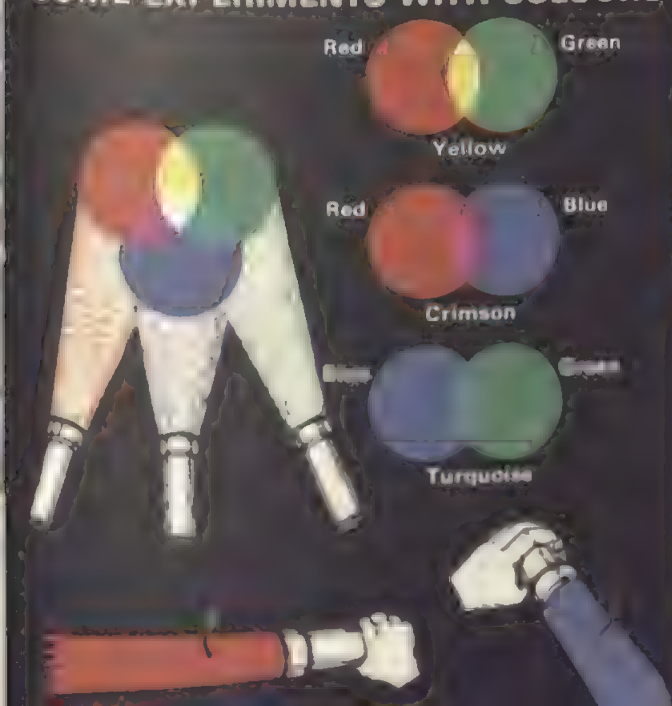
1. Copy the coloured circles shown in the black frames opposite. Use a pencil and a penny to draw the circles. Colour the insides of the circles with paint.
2. Write a few sentences about colours.
3. Look up the words "absorbs" and "transparent" in a dictionary and find out what they mean.

Colours

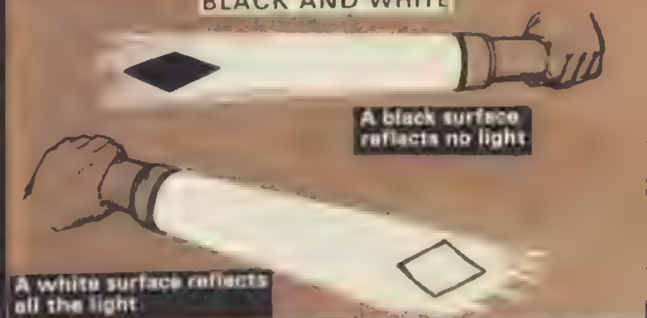
PRIMARY COLOURS

SECONDARY COLOURS

SOME EXPERIMENTS WITH COLOURS



BLACK AND WHITE



COLOUR BLINDNESS

In one kind of colour-blindness, a person is not able to tell the difference between green, yellow and orange

13 Evergreens

Trees in winter

In winter, most trees are without leaves. They shed their leaves in autumn.

But, some trees have leaves during the winter. These trees are called *evergreens* because they are "ever green" or "always green". Their leaves are tough, like leather, and are not easily killed by cold weather.

Evergreens

The evergreens shed their leaves, but only a few at a time, and so they have leaves throughout the year. Some well-known evergreens are pine trees, fir trees and the holly and the mistletoe.

Two kinds of trees

There are two kinds of trees – *deciduous* and *coniferous*.

Deciduous trees have fruits. These fruits contain seeds. Deciduous trees shed their leaves in autumn. Holly and mistletoe are exceptions. They do not shed all their leaves in autumn. They are evergreens.

Coniferous trees are also called *conifers*. Conifers have cones that are made of *woody scales*. These cones contain seeds. Conifers are evergreens. Larch is an exception. It sheds all its leaves in autumn.

Some common trees are shown opposite.

Collecting cones

Collect some fallen cones. Bring them to school and make a display of them. Your teacher and your class-mates will help you to find out their names. Print their names on paper labels. Glue the labels to the cones.

Holly

Holly was once called the *holy tree* because of its use as a decoration in churches at Christmas-time. It has dark green, prickly leaves and red berries. Holly flowers are white.

Dry holly is sometimes used as a fuel. It burns with clear, hot flames. Holly is useful in hedges because farm animals will not eat its prickly leaves. Holly branches make good walking-sticks.

Burning holly

Ignite a few dry holly leaves on a lid from a biscuit tin. Notice how well they burn.

Mistletoe

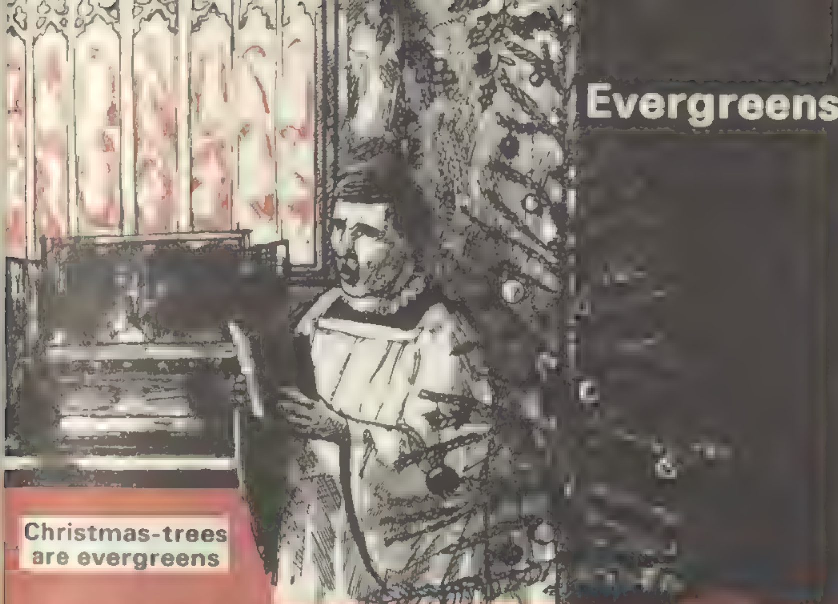
Mistletoe has slender, pale-green leaves and white berries. It is a *parasite*. It depends on other plants for its food. It cannot grow in the ground. It must grow on the branches of other trees. It is often found on apple trees.

When a mistletoe seed lands in a crack on the bark of a tree branch, it grows little roots which become firmly fixed to the branch.

MORE THINGS TO DO

1. Make a list of 10 deciduous trees.
2. Make a list of 6 conifers.
3. Draw sprigs of holly and mistletoe. Colour the leaves green and the holly berries red.
4. Collect holly and mistletoe branches, but not without permission, and use them as a Christmas decoration for your classroom.
5. Look up the word "parasite" in a dictionary and find out what it means

Evergreens

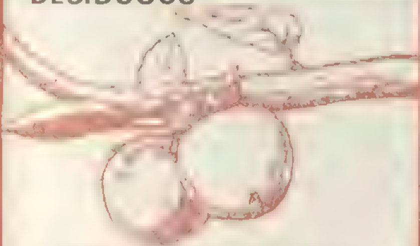


Christmas-trees are evergreens

The leaves of evergreens are tough, like leather

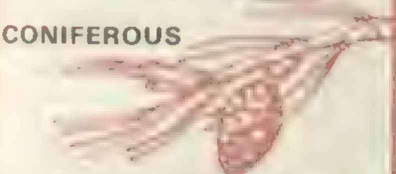
TWO KINDS OF TREES

DECIDUOUS



Seeds in fruits. Shed their leaves in autumn

CONIFEROUS



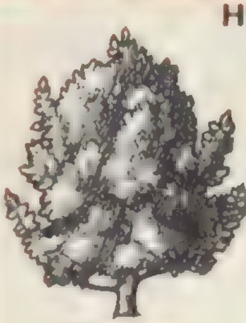
Seeds in cones. Evergreen.

SOME DECIDUOUS TREES

SOME CONIFERS

COLLECTING CONES

HOLLY

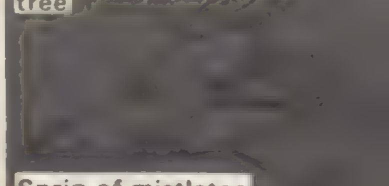


Holly tree

Sprig of holly

MISTLETOE

Mistletoe on an apple tree



Sprig of mistletoe

14 Photography

A light-sensitive chemical

Fill a glass jar with water. Stir half a teaspoonful of *silver nitrate* crystals in the water so that they dissolve to make a *silver nitrate solution.* You notice that this solution is colourless.

Then, stir a teaspoonful of table salt into the silver nitrate solution. At once, the solution becomes white and cloudy. A chemical change takes place and a white *suspension* of *silver chloride* is formed. Silver chloride does not dissolve in water.

Table salt (*sodium chloride*) + silver nitrate = *sodium nitrate* + silver chloride.

Stand the jar in sunlight for some time. The colour of the silver chloride changes from white to purple-grey. Silver chloride is sensitive to light.

Photography

Photography became possible when it was discovered that some chemicals are sensitive to light.

The first photographs were made nearly 200 years ago. "Photograph" means "light picture". They were images formed on glass plates that had been coated with light-sensitive chemicals. These early photographs were not very good. They were not permanent; they became darkened all over when they were exposed to light for some time.

Nowadays, films are coated with a jelly-like substance, called *gelatine*, that contains *silver salts*.

Developing and printing

What do you do when you have used up all the film in your camera? Of course, you unload the film, taking care that none of it becomes exposed to the light. Then, you leave the film at a chemist's shop. After a few days, the finished photographs are ready for you.

Briefly, this is what happens at the chemist's shop. The film is treated with a special chemical solution. The pictures appear. They are the "wrong way round". The parts that have received the most light become the darkest; the parts that have received the least light become the lightest. This is called *developing*. The developed pictures are called *negatives*. Then, the developed film is treated with a *fixing solution*. This makes the pictures permanent.

The finished pictures are made from the negatives. This is called *printing*. The finished pictures are called *prints*. The prints are the "right way round". The dark parts on the negatives are light on the prints; the light parts on the negatives are dark on the prints.

Blue-prints

Blue-print paper is coated with a light-sensitive chemical. It turns blue when exposed to the light. It is used for making copies of the drawings of architects and draughtsmen.

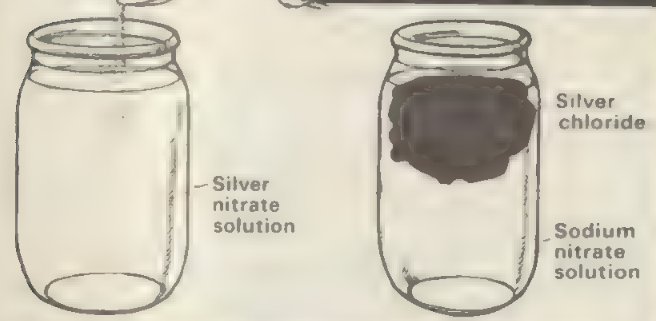
Making a blue-print

Make a blue-print in the way shown opposite. Paste it into your notebook.

MORE THINGS TO DO

1. Copy the simple drawings of a negative and a print shown opposite.
2. Find an old photographic negative. Paste it into your notebook.
3. Write a short essay with the title *Photography*.

A LIGHT-SENSITIVE CHEMICAL



Sodium chloride + silver nitrate = sodium nitrate + silver chloride

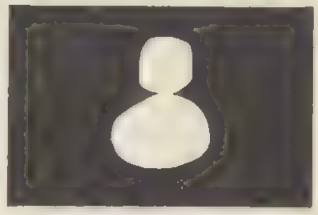
EARLY PHOTOGRAPH

Photography

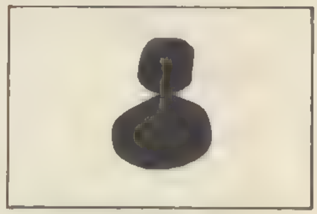
NEGATIVE

PRINT

SIMPLE DRAWINGS OF A NEGATIVE AND A PRINT



Negative



Print

MAKING A BLUE-PRINT

1. Make a "negative" by using a black crayon to draw a picture on tracing paper
2. Use paper clips to fix the "negative" over a sheet of blue-print paper

3. Stand the "negative" and blue-print paper in bright sunlight for a few hours
4. Remove the "negative"

5. Wash the print in water This fixes the print. No fixing solution is needed
6. The finished print

15 Pendulums and levels

Two useful inventions

Of all our inventions, two of the simplest, and yet the most useful, are the *pendulum* and the *spirit-level*.

Pendulums

Pendulums are used in mechanical clocks. Perhaps you have seen the pendulum of a *grandfather clock*. The pendulum is made to swing by a weight that falls slowly. Each swing of the pendulum from one side to the other takes ½ second. When the weight is lifted, the clock is "wound up".

The pendulum was invented by an Italian, Galileo Galilei. It is said that, while he was at a service in the cathedral at Pisa, in Italy, he watched the swinging of a chandelier. He noticed that, though its swings became shorter, the time for each swing remained the same.

The period of a pendulum

For a long swing, a pendulum moves quickly; for a short swing, a pendulum moves slowly. The time for each swing does not change.

The time that a pendulum takes to make a swing from one side to the other is called its *period*. The period of a pendulum depends on its length.

Inside a clock

Perhaps your teacher has a pendulum clock that he will allow you to examine.

Open the back of the clock and look for the pendulum. Watch its swings. How long does the pendulum take to make one swing?

Making a pendulum

Make a pendulum.

Fix a lump of plasticine on one end of a cotton thread that is about 1 metre long. Tie the other end of the thread to a support. Tap the plasticine *bob* to start it swinging.

Watch the seconds hand of a watch and, at the same time, count the number of swings that the pendulum makes in 60 seconds. Calculate the period of the pendulum.

Period, in seconds, $= 60 \div$ number of swings.

Now, shorten the cotton thread and, again, find the period of the pendulum.

Spirit-levels

Spirit-levels are used by builders and engineers to check that surfaces are *horizontal*. "Horizontal" means "level with the ground".

A spirit-level is a glass tube that contains spirit, usually coloured green, with a small air bubble inside it. Water could be used in the tube but spirit does not "stick" to its sides.

Using a spirit-level

Examine a spirit-level. Can you see the air bubble?

Place the level on a horizontal surface. Where is the air bubble?

Now, place the level on a sloping surface. Where is the air bubble?

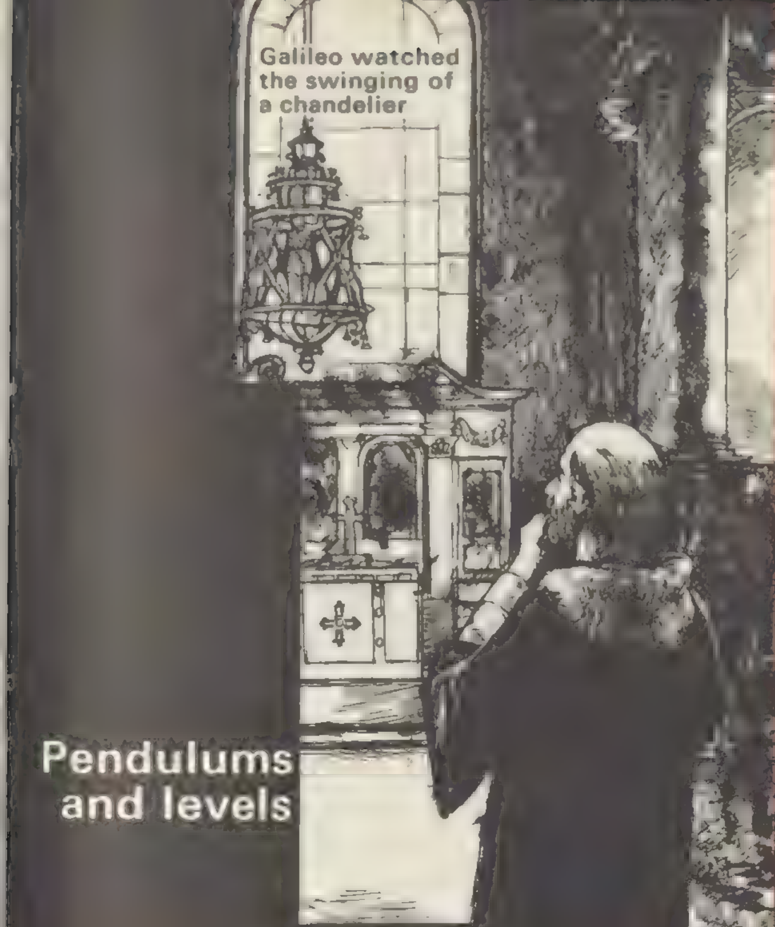
Making a "bottle level"

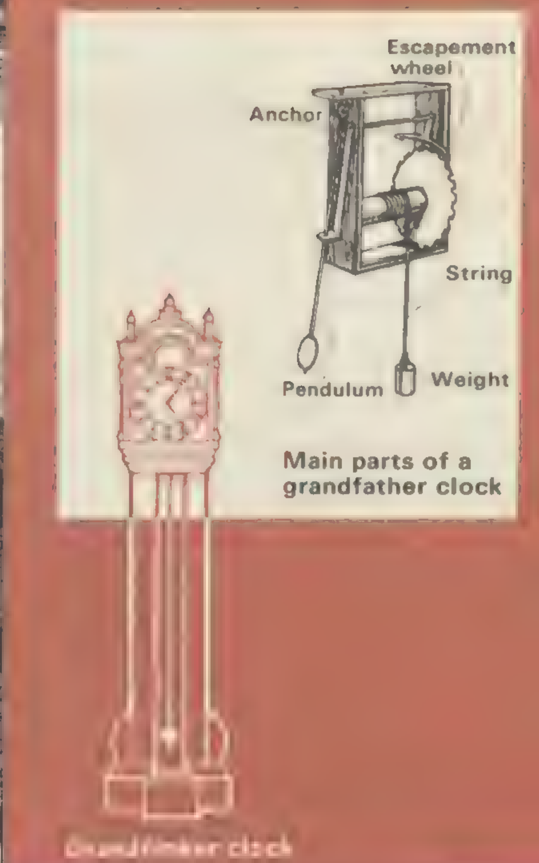
Make a "bottle level" in the way shown opposite.

MORE THINGS TO DO

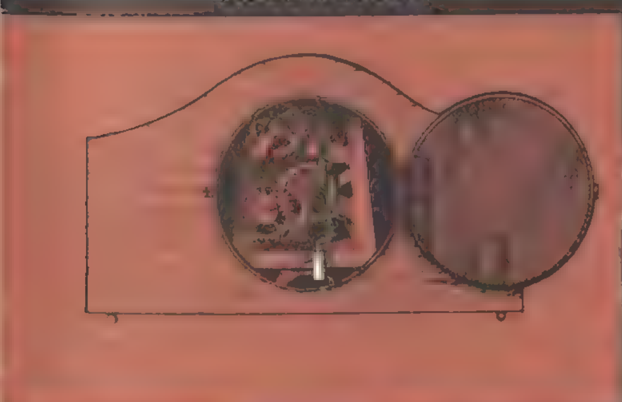
1. Write a few sentences about pendulums.
2. Draw a spirit-level.

Pendulums and levels

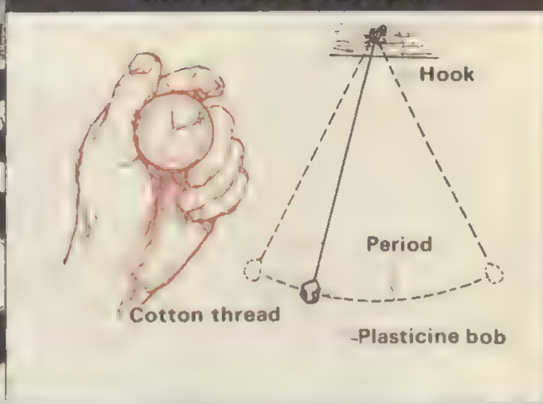




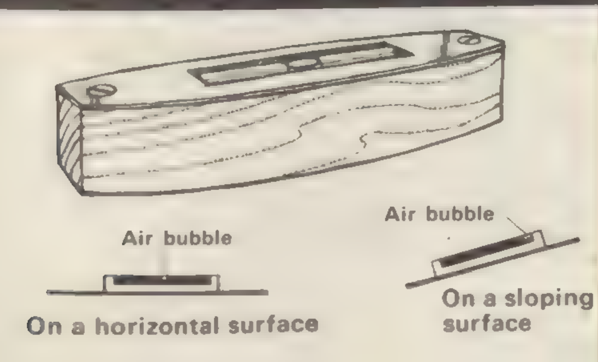
INSIDE A CLOCK



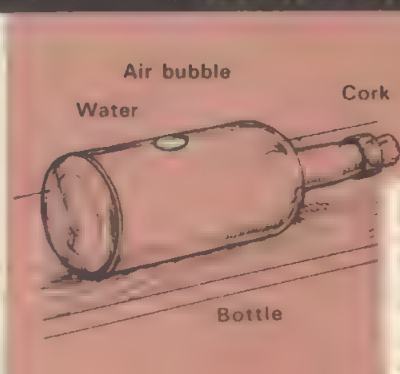
MAKING A PENDULUM



SPIRIT-LEVEL



MAKING A "BOTTLE LEVEL"



16 Pens, ink and paper

Writing and pens

When you write, you use a ball-point pen, a fountain pen, a "dip-in-the-ink" pen, a pencil or a crayon.

A Chinaman does his writing with a brush. Perhaps you have noticed that Chinese letters are quite thick.

In the Middle Ages, a monk did his writing with a *quill pen*. A quill is a feather. The end of the quill was kept sharp with a knife.

The people of Ancient Rome did their writing with a sharp, metal instrument called a *stylus*. They wrote on clay or wax tablets.

A very long time ago, before either pens or writing had been invented, people scratched simple picture-messages on wood and stones.

Looking at a pen-nib

Look at a pen-nib. What is the purpose of the slit? (See Chapter 8, Book Two.)

Making a quill pen

Use a sharp knife to cut the point of the shaft of a goose feather so that it is square. Dip the point into ink. Notice that a little ink is stored in the shaft. Write a few words in your notebook - upstrokes thin and downstrokes thick.

Writing on wax

Put some pieces of wax candle in a metal lid. Heat the lid. The wax melts. Then, allow the wax to cool. Scratch a few words on the surface of the wax. Use a nail or a needle as a stylus.

Ink

Nowadays, you can buy inks of all colours and for all purposes.

The ink used by printers is a mixture of oil and soot.

The first inks were fruit juices and coloured clays stirred up in water.

Some simple inks

Dip the end of a match-stick into some blackcurrant juice. Then, write a few words in your notebook.

Mix a little water with some red clay in a saucer. Make a paste. Dip your forefinger into the paste. Then, draw a simple picture on some white paper.

Making printers' ink

Use the end of an old knife to mix together, on a piece of cardboard, a little soot and a little vaseline. Try out this ink with a *lino-cut*.

Paper

The Ancient Egyptians wrote on strips taken from the stems of *papyrus* plants. The word "paper" comes from the word "papyrus".

Some paper is made from old rags, but most paper is made from wood. The important stages in the manufacture of paper are shown opposite.

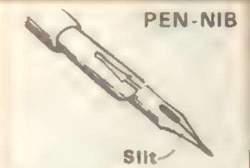
Many things are made from paper. Some of these things are shown opposite.

MORE THINGS TO DO

1. Draw a quill pen.
2. Make a list of some of the things that are made from paper.
3. Paste a lino-cut print into your notebook.
4. Visit a printing-works if you get a chance.

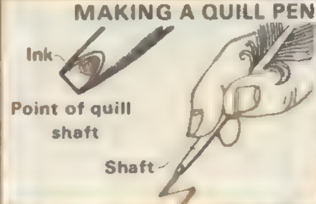
Pens, ink and paper

PEN-NIB

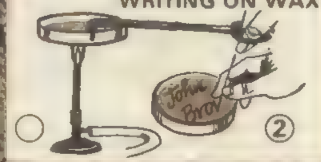


What is the purpose of the slit?

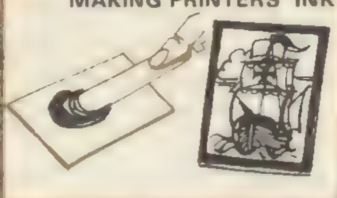
MAKING A QUILL PEN



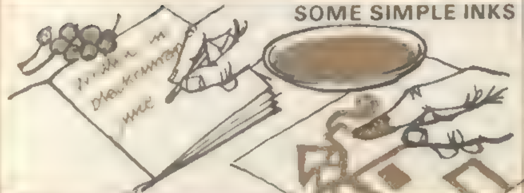
WRITING ON WAX



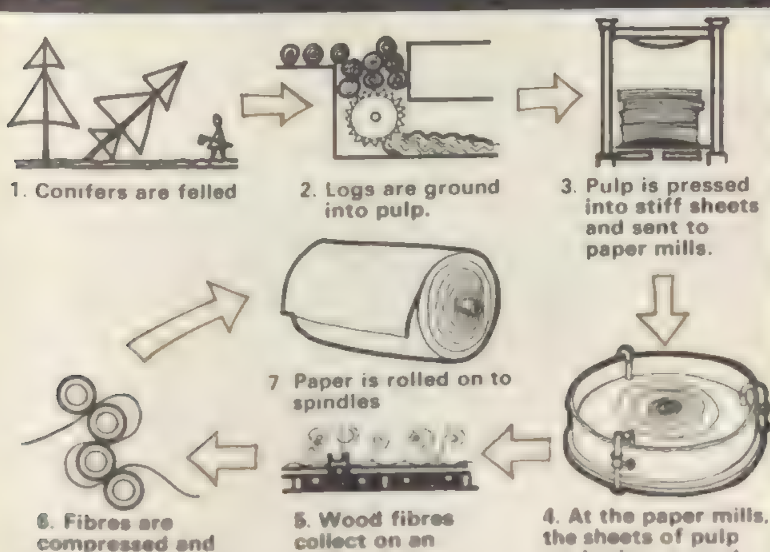
MAKING PRINTERS' INK



SOME SIMPLE INKS



PAPER MANUFACTURE



1. Conifers are felled
2. Logs are ground into pulp.
3. Pulp is pressed into stiff sheets and sent to paper mills.
4. At the paper mills, the sheets of pulp are broken up and mixed with water
5. Wood fibres collect on an endless belt.
6. Fibres are compressed and dried
7. Paper is rolled on to spindles

MADE FROM PAPER

17 "Nylons"

A pair of stockings

When your mother goes into a shop to buy a pair of stockings, it is more than likely that she will ask for some "nylons". Stockings are made from thin threads of a material that is called *nylon*.

Textiles

Nylon is a *textile*. A textile is something that can be woven into fabric. Cotton, wool, linen, silk, nylon and *rayon* are textiles.

Cotton, wool, linen and silk are called *natural fibres* because they are obtained from plants and animals.

Nylon and rayon are called *man-made fibres* because they are made artificially.

Many useful things are made from textile fabrics. A few of them are shown on the page opposite.

Natural fibres

At one time, before the invention of man-made fibres, all our textiles were made from natural fibres. Many of our textiles are still made from natural fibres.

Cotton is made from the white hairs on the seeds of the cotton plant. Sails and ropes are made from fibres obtained from *hemp* stems. Linen is made from fibres obtained from *flax* stems.

Wool comes from sheep. Silk is made by *silkworms*.

Man-made fibres

Man-made fibres are stronger, thinner, longer, harder-wearing and more flexible than natural fibres. Also, some man-made fibres are very resistant to heat and moisture.

Nylon is made from coal. Rayon is made from wood. Rayon is sometimes called *artificial silk* or *art silk*.

Most man-made fibres are manufactured in the same way. Coal or wood is treated with chemicals so that it becomes a liquid. The liquid, under pressure, is squeezed through fine nozzles. The jets of liquid become solid fibres. The fibres are twisted together to make a thread.

Real silk

Real silk is made by silkworms. Silkworms are not worms. They are the caterpillars of the *silk moth*.

Real silk is very expensive. Many thousands of silkworms are needed to provide enough silk to make a single silk dress.

Keeping silkworms

Keep some silkworms in the way shown opposite.

Watch the growth of the silkworms. They moult their skins four times.

You will need about two dozen eggs of the silk moth. These can be purchased. You could write to this address and ask for details.

The Butterfly Farm Ltd.,
42 Salisbury Road,
Bexley, Kent.

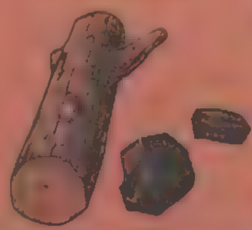
MORE THINGS TO DO

1. Draw a silk moth.
2. Make a list of textiles.
3. Write one sentence about each of these words in a way which shows that you know what the word means.

   Textile; nylon; rayon; flax; hemp; silkworm.
4. Use an encyclopedia to find out what you can about *spinning* and *weaving*.

"Nylons"

MAN-MADE FIBRES

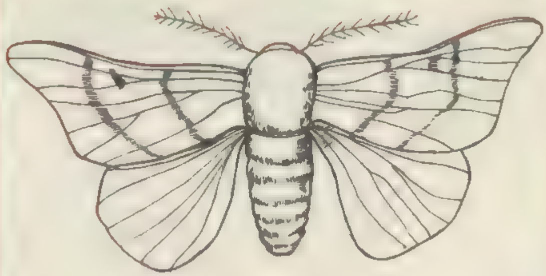


Man-made fibres are manufactured from coal and wood

The wood or coal, after treatment with chemicals, is squeezed through fine nozzles

The fibres are twisted together to make a thread

NATURAL FIBRES



SILK MOTH

KEEPING SILKWORMS

A silk moth egg is about as big as a pin-head

Make a cage for your silkworms. Use a shoe-box and a piece of muslin.

Remove the top of the lid and use the sides to hold the muslin in place.

Place some silk moth eggs in the cage and stand it near a radiator.

Feed the silkworms twice each day on mulberry or lettuce leaves. Remove the uneaten leaves.

Watch the growth of the silkworms. They are full-grown after about 5 weeks.

Put each full-grown worm in a paper bag where it can spin its cocoon

Drop the cocoons into hot water

Wind the silk on to a strip of card.

18 The fox and the badger

The fox

When you are out in the country at night during the middle of winter, you may hear a fox yapping to his mate.

Very soon, they will be making a home in a hole in a bank. They might use a rabbit burrow. They will kill or frighten away the rabbits and then dig out the burrow to make it larger.

The fox's home is called an *earth*. Inside it, the mother fox looks after her family of puppy-like *cubs*.

A female fox is called a *vixen*. A male fox is called a *dog-fox*.

The fox has dirty habits. He does not clean out his earth, and he is quite content to sleep among the bones, feathers and bits of skin from the animals that he has eaten.

He eats almost any kind of animals – beetles, frogs, mice, hens, ducks, rabbits and even rats.

The fox is destructive. He will kill all the chickens in a fowl-house, though he wants to eat only one of them. He is a great nuisance to farmers.

There are many stories about the cunning ways of *Sly Reynard*, as the fox is sometimes called. His keen ears detect every sound and his sharp nose picks up every scent. He soon knows if huntsmen and their hounds are about.

His red-brown coat helps him to hide among bushes and fallen leaves. The underpart of his body is white. The tip of his long bushy tail is black or white.

The badger

The badger is rarely seen or heard because he is shy and peaceful. Country people call him *Old Brock*.

His home, which is called a *sett*, contains many deep tunnels and has several entrances. He sleeps on a warm bed of dry leaves and moss. He cleans out his sett quite often, as is shown by the heaps of leaves outside it.

Most of his body is grey, but his legs and underparts are black. His face is striped black and white. His hair is bristly.

Though the badger is peaceful, he will fight bravely when dogs attack him. The claws on his front feet are strong and very sharp.

He sleeps during the day and comes out at night to look for food. He eats beetles, slugs, worms, grubs, mice, frogs, bark, roots and berries.

The badger stays in his sett in the winter, but he will come out for food during fine spells.

British mammals

The fox and the badger live wild in Great Britain. They are warm-blooded and have four legs. They do not lay eggs. They give milk to their babies. They are *mammals*.

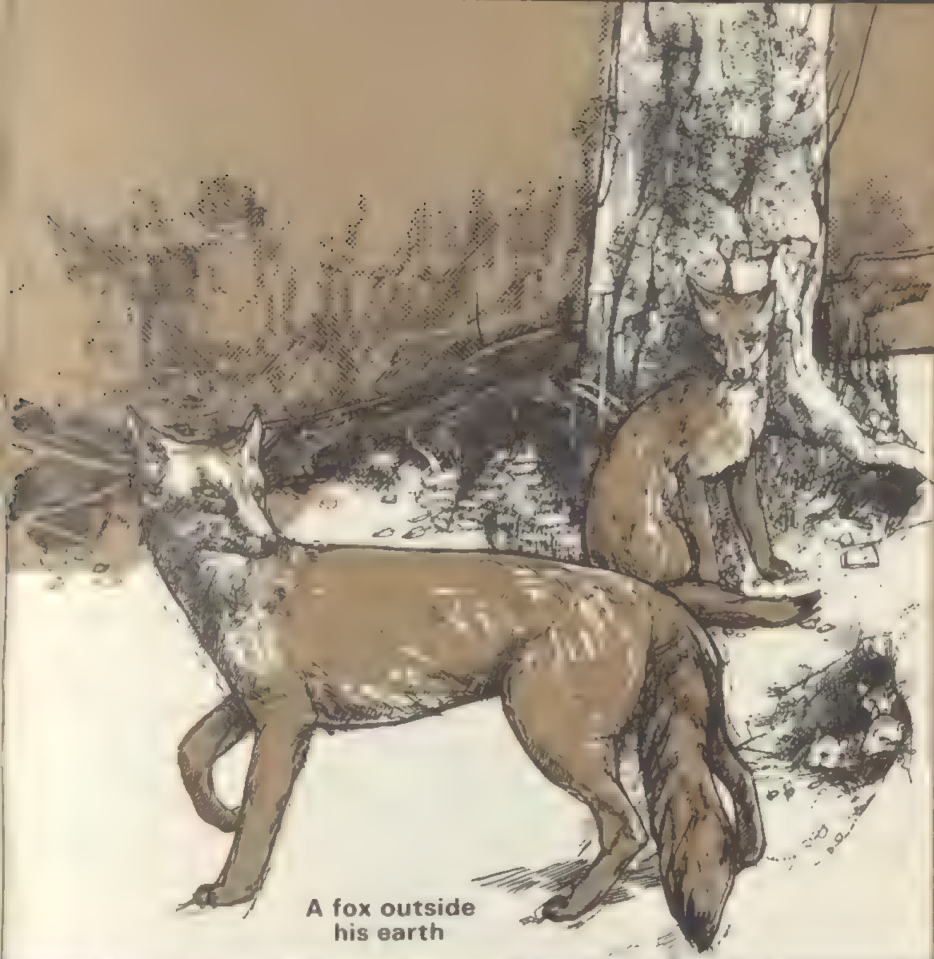
Some other British wild mammals are shown opposite.

MORE THINGS TO DO

1. Draw a fox and a badger. Colour the drawings.
2. Write a few sentences about *either* the fox *or* the badger.
3. Write down another name for each of these things.

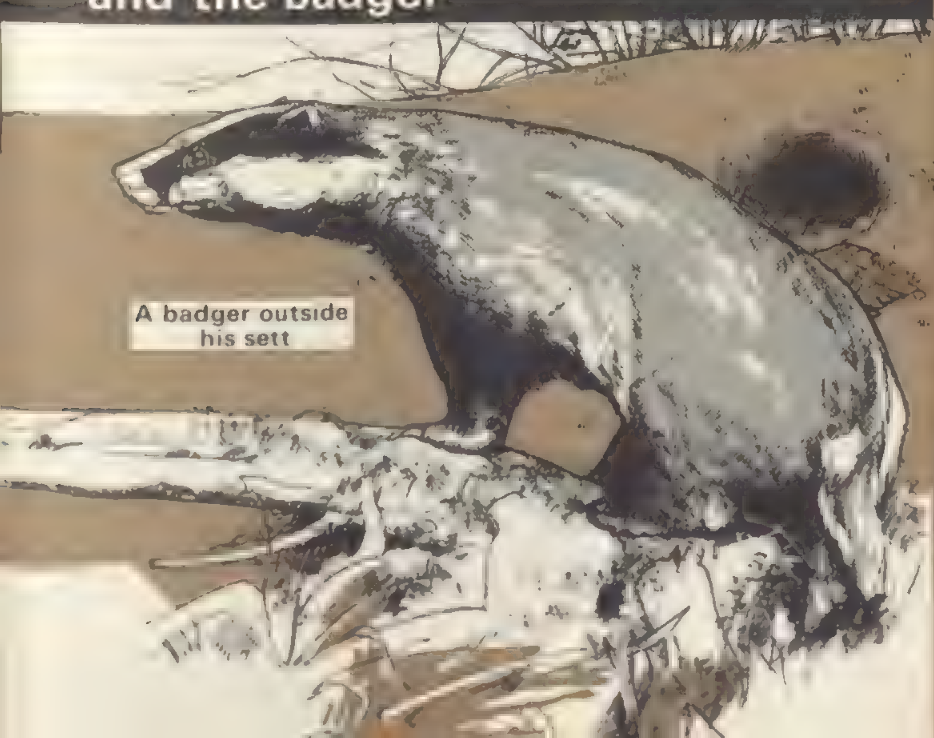
Fox's home; baby fox; female fox; male fox; Sly Reynard; Old Brock; badger's home.

4. Make a list of British mammals.



A fox outside his earth

The fox and the badger



A badger outside his sett

19 History in the rocks

Past ages

It is believed that the earth is more than 2,000 million years old.

The time-chart opposite shows some of the past ages of the earth. Look at it carefully. Now, answer these questions.

1. How old are the oldest rocks? 2. When did life begin? 3. How old are most *fossils*? 4. When were the coal seams formed? 5. When did the first reptiles appear on the earth?

It is probable that there have been men on the earth for about a million years, but this is a short period of time compared with the age of the earth.

The earth's history

Written history, which was made possible by the invention of writing, pens and paper, goes back for only a few thousand years, and that is not always reliable. But, the earth is millions of years old. How, then, do we know so much about its history? The earth's history is found in the rocks. Scientists know much about rocks and how they change as time goes by. This enables scientists to decide when the different rocks were formed. The preserved remains of plants and animals are found in certain rocks. These remains are called fossils. They show the kinds of life that were on the earth in past ages.

Archeologists have found cave drawings and buried tools, weapons, ornaments, etc. These finds have told archeologists about the activities and habits of early men. An archeologist is a man who studies ancient objects.

Fossils

Some fossils are shown opposite.

Pieces of coal sometimes have imprints made by fossilized plants. Fossilized shells are found in chalk and limestone. Teeth and bones, millions of years old, have been found in rocks and sand. Limestone and chalk are made of animal skeletons.

Looking at fossils

Look at any available fossils and pieces of chalk, coral, coal, etc. Which things are plant? Which are animal?

Prehistoric animals

Some of the giant reptiles and mammals which lived on the earth about 200 million years ago are shown opposite. They are sometimes called *prehistoric animals*. "Prehistoric" means "before history". The *pterodactyl* was a flying reptile.

Extinct animals

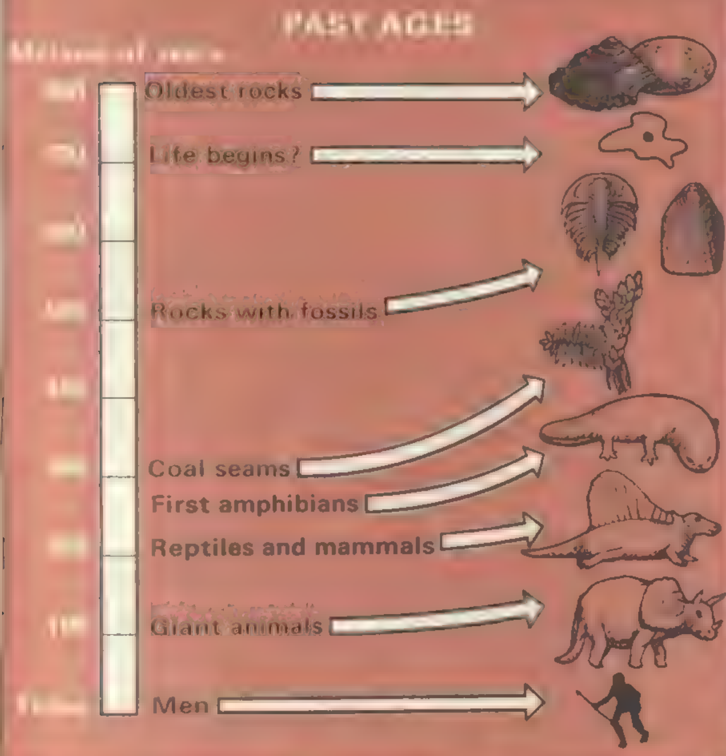
The giant reptiles and mammals became *extinct* when the earth's climate became cooler and drier.

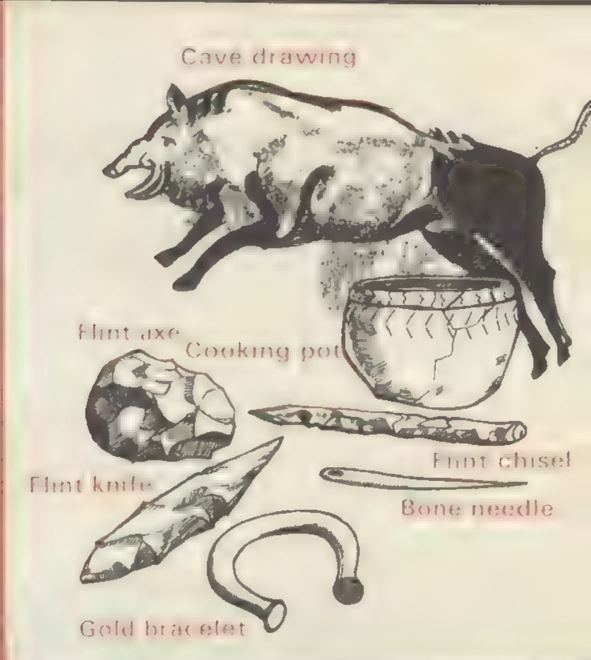
Animals have become extinct in recent times. The *dodo*, a flightless bird, last seen on the island of Mauritius, and the *quagga*, a zebra-like animal, are two good examples. Large herds of bison once roamed the vast plains of North America. Today, there are only a few bison, protected in Canadian parks.

MORE THINGS TO DO

1. Draw one of the prehistoric animals shown opposite.
2. Write a few sentences about fossils.
3. Look up the word "extinct" in a dictionary and find out what it means.

History in the rocks





20 Some useful rocks

Useful rocks

The earth's crust contains some very useful rocks. Some of the most useful are granite, clay and the other rocks that are used for making building materials.

Building materials

How are rocks made into building materials?

Sandstone, granite, marble and other hard rocks are cut into blocks.

Ordinary building bricks are moulded out of wet clay. The bricks are hardened by heating them in a furnace.

Roofs are covered with *tiles* or *slates*. Tiles are moulded out of clay. Slate is clay that has been covered and compressed by rocks in the earth's crust. Slate is much harder than clay.

Mortar, which is used for holding bricks together, is a mixture of sand, water and either *slaked lime* or cement. As mortar dries out, it becomes hard.

Cement is made from lime and special kinds of clay.

Concrete is a mixture of cement, sand and pebbles or granite chippings.

Chalk, limestone and marble

Chalk, *limestone* and *marble* are three common and useful rocks. They have been formed from the skeletons of tiny sea-animals that are called *foraminifera*. Their skeletons are made of *calcium carbonate*. They make this calcium carbonate from the *lime* in sea-water.

When foraminifera die, they fall on to the bed of the ocean where the soft parts of their bodies decay and their hard skeletons are left behind. Layers of these skeletons, formed millions of years ago, have been raised above the ocean by movements in the earth's crust. The chalk cliffs at Dover were probably formed in this way.

Chalk is soft. But, if it is covered and compressed by other rocks, it becomes hard. Then, it is called limestone. If it is compressed even more, it becomes very hard. Then it is called marble.

Calcium carbonate

Chalk, limestone and marble are three different forms of calcium carbonate. Calcium carbonate contains carbon dioxide. If calcium carbonate is heated strongly, it gives off carbon dioxide gas and lime is left behind.

Carbon dioxide from chalk

Put a teaspoonful of powdered chalk in a jar. (Note: blackboard chalk is not real chalk.) Pour a little vinegar into the jar. Notice the fizzing.

Put a little lime-water in a test-tube. Pour some of the gas from the jar into the test-tube. Hold a finger over the mouth of the test-tube and shake it well. The lime-water becomes cloudy. What does this show?

Making quicklime and slaked lime

Make *quicklime* and *slaked lime* in the way shown opposite.

MORE THINGS TO DO

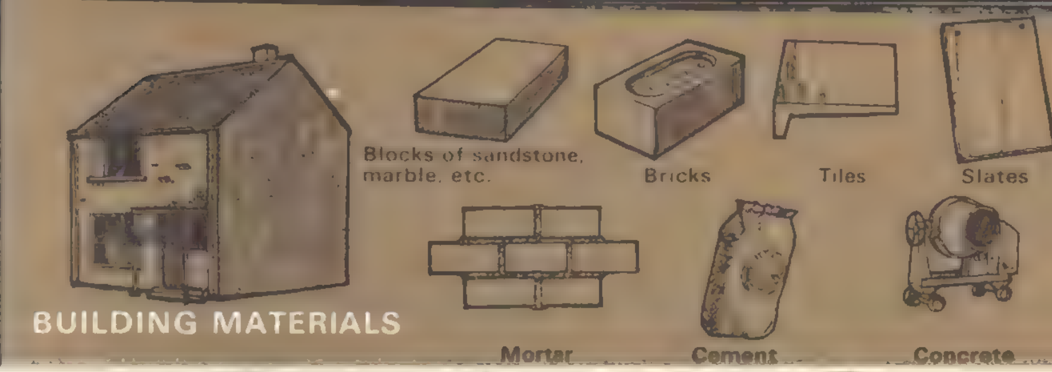
1. Copy the drawing shown in the black frame opposite.

2. Draw one of the foraminifera shown opposite.

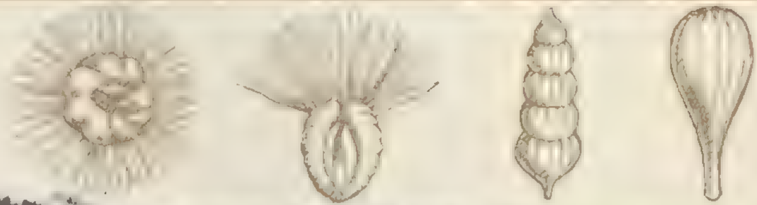
3. Write one sentence about each of these things.

Slate; mortar; cement; concrete; chalk; limestone; marble; quicklime.

Some useful rocks

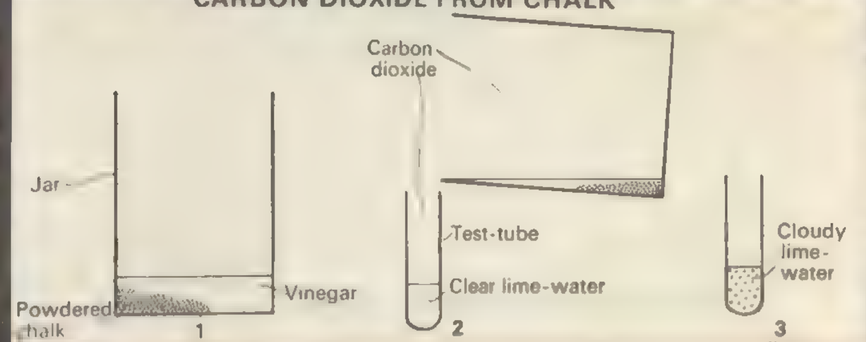


FORAMINIFERA

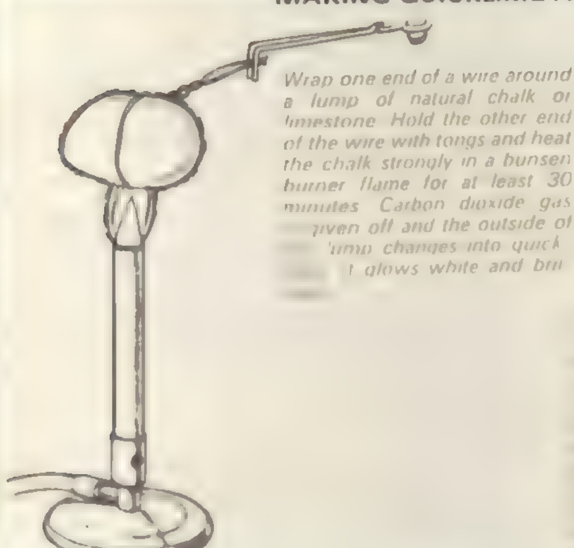


Chalk cliffs

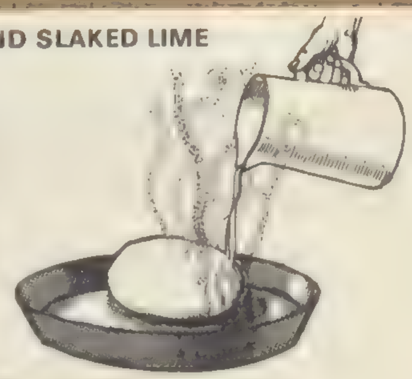
CARBON DIOXIDE FROM CHALK



MAKING QUICKLIME AND SLAKED LIME



Wrap one end of a wire around a lump of natural chalk or limestone. Hold the other end of the wire with tongs and heat the chalk strongly in a bunsen burner flame for at least 30 minutes. Carbon dioxide gas ... given off and the outside of ... lump changes into quick... ... t glows white and bri...



When the quick... lime is cool plac... t in a metal d... Drip water on t... the quickli...

21 Glass

Glass-making

Glass is made by heating a mixture of sand and certain chemicals to a high temperature so that they melt. It is probable that the first glass was made accidentally when the sand under a cooking pot became very hot and melted.

The common glass used for making bottles and windows is made from a mixture of sand, *soda* and lime. Certain chemicals are put into glass to give it colour or to make it suitable for special work.

Glass-blowing

Many of our bottles and glass vessels are still made by *glass-blowers*. Have you ever seen a glass-blower at work? He heats one end of a long glass tube until it melts. He blows down the other end of the tube. This causes the molten end to swell. It is then moulded into the shape that is required.

Made from glass

Jugs, vases, tumblers, bottles, dishes, windows and artificial jewellery are some of the things that are made from glass. Can you think of any others?

Sodium in glass

Use tongs to pick up a small piece of *washing soda* and hold it in a bunsen burner flame. The flame becomes orange-yellow in colour. This is because washing soda contains the metal *sodium*. What is the colour of the light from a sodium-vapour lamp?

Then, use tongs to pick up a short length of tube made of *soda-glass* and hold it in the bunsen burner flame. The flame becomes orange-yellow. What does this show?

Glass-working

Now, try to do some work with a glass tube.

1. *Cutting*. Use a triangular file to scratch a mark about 20 centimetres from the end of a glass tube. Tap the glass tube sharply on a desk top. The tube breaks at the mark.

2. *Fire-polishing*. Hold one end of the tube with your fingers. Rotate the other end in a bunsen flame. The jagged ends of the tube melt and become smooth. Place the tube on a building brick. When the tube is cool, polish the other end.

3. *Sealing*. Hold one end of the tube with your fingers and rotate the other end in the bunsen flame until the glass is soft. Seal the tube by squeezing the molten end gently with tongs.

4. *Bending*. Hold each end of the tube with your fingers. Rotate the middle of the tube in the bunsen flame. Bend the tube gently to make a right angle.

5. *Stretching*. Cut off another 20-centimetre length of glass tube. Rotate the middle of the tube in the bunsen flame. Very gently, pull the ends of the tube apart so that the tube stretches at its middle. When the tube is cool, tap it on a desk top. The tube breaks. You now have two glass jets.

MORE THINGS TO DO

1. Draw a glass-blower at work.
2. Make a list of things that are made from glass.

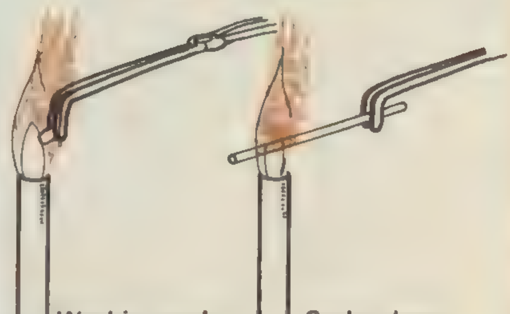
Glass

The first glass was made accidentally when the sand under a cooking pot became very hot and molten

Glass-blower at work

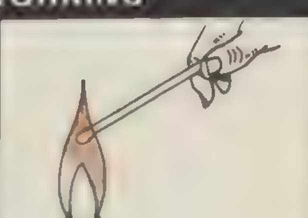
MADE FROM GLASS

SODIUM IN GLASS

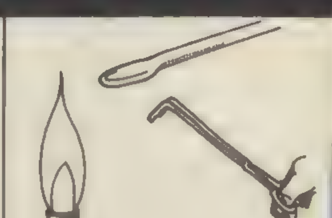


GLASS-WORKING

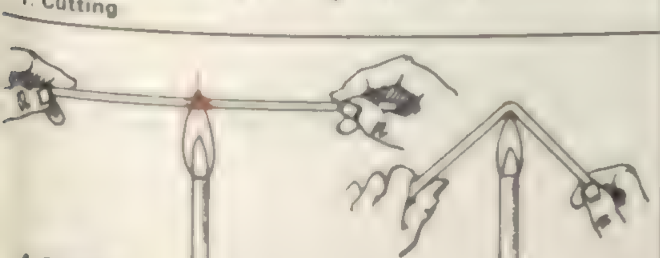
1. Cutting



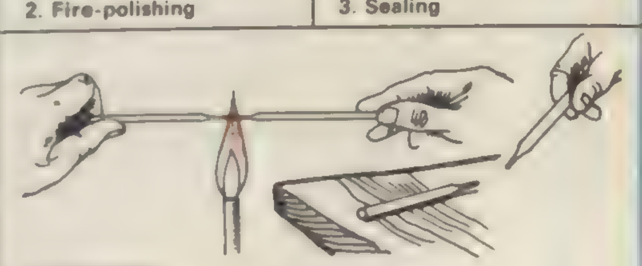
2. Fire-polishing



3. Sealing



4 Bending



5 Stretching

22 The elements

Chemistry

What is *chemistry*? It is the science of materials – what chemicals they contain and what new materials can be made from them. Chemists know how to make cements, plastics, cosmetics, medicines and many other useful things from such materials as rocks, coal, oil, etc.

Chemistry and magic

In the Middle Ages, chemistry was known as *alchemy*. It was a strange mixture of magic and real chemistry.

The *alchemists* of the Middle Ages spent most of their time trying to discover an *elixir* which would enable them to live for ever and turn all metals into gold. Of course, they were not successful.

The people of the Middle Ages were very superstitious. Many alchemists were accused of witchcraft and were burned alive as a punishment. No wonder that most alchemists kept their work secret. They wrote in code.

The four elements

Some Ancient Greeks believed that all materials were made of one or more of four *elements* – *air*, *fire*, *earth* and *water*. They were wrong, but their belief was quite reasonable. After all, water oozes out of the ends of a damp, burning log; it gives fire, smoky vapours, or "air", and ash, or "earth".

The elements

In actual fact, there are about 96 elements. *An element is a substance that cannot be separated into simpler substances.* Water is not an element because it can be separated into hydrogen and oxygen. Hydrogen and oxygen are elements; they cannot be separated into simpler substances. The commoner elements are shown opposite.

Compounds

Substances which contain two or more elements joined together chemically are called *compounds*. A compound is different from the elements that are contained in it. For example, iron can be magnetized and sulphur is yellow, but *iron sulphide*, which is a compound of these two elements, is not magnetic and is dull-grey in colour. Some common compounds are shown opposite.

Making a compound

1. Place a little *flowers of sulphur* and iron filings in a saucer. What are the colours of these substances? Use a small spoon to mix the two substances together. Bring a magnet near to the mixture. What happens?

2. Put a little of the mixture in a test-tube. Heat the test-tube in a bunsen burner flame. A red glow spreads through the mixture.

3. When the test-tube is cool, tap it on the edge of the saucer. A lump of dull-grey iron sulphide slides into the saucer. Bring a magnet near to the iron sulphide. Is it magnetic?

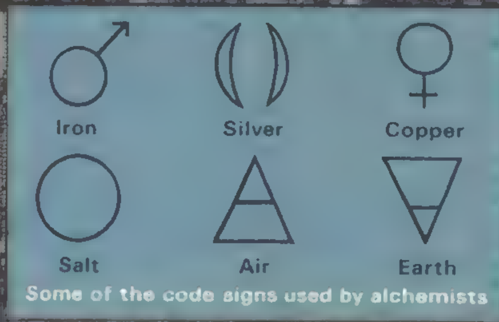
MORE THINGS TO DO

1. Copy the drawing shown in the black frame opposite.
2. Make a list of the commoner elements.
3. Copy the table of common compounds shown opposite.
4. Look up the word "elixir" in a dictionary and find out what it means.

The elements

Alchemists were burned alive as punishment for witchcraft

The people of the Middle Ages believed that alchemists practised the Black Art and were in league with the Devil



Some of the code signs used by alchemists

THE COMMONER ELEMENTS

METALS

Calcium
Potassium
Sodium
Iron
Mercury
Lead
Copper
Zinc
Tin
Aluminium
Gold
Silver
Magnesium
Nickel

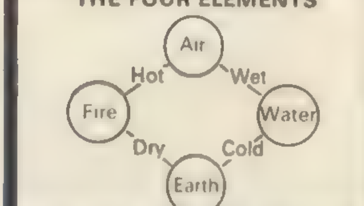
NON-METALS

Hydrogen
Carbon
Chlorine
Sulphur
Phosphorus
Silicon
Nitrogen
Iodine

THE FOUR ELEMENTS OF THE ANCIENT GREEKS

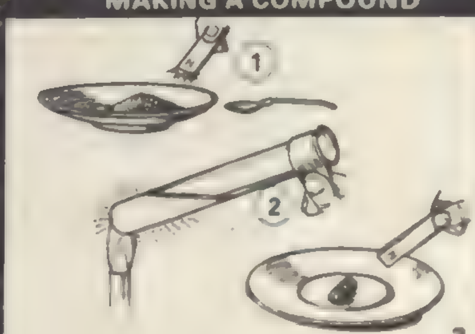
Burning log

THE FOUR ELEMENTS



Qualities caused by the mixing of the elements

MAKING A COMPOUND



SOME COMMON COMPOUNDS

Compound	Elements in it
[illegible]	Iron, sulphur
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

23 The mighty atom

Atoms

If all materials are made of elements, what are elements made of? Elements are made of *atoms*. Imagine that you have a magic knife with which you cut a piece of iron, first into 2 pieces, then into 4 pieces, then into 8 pieces, and so on. Eventually, you will reach a stage where you will not be able to cut the pieces to make them any smaller. You will have millions of pieces of iron. These pieces will be atoms. Atoms are very tiny. You cannot see a single atom with your eyes. The head of a pin contains many millions of atoms of iron.

An atom is the smallest possible part of an element. All the atoms of one element are exactly the same in size and weight, but atoms of different elements have different sizes and weights. For example, an atom of oxygen is 16 times heavier than an atom of hydrogen.

What is an atom?

At one time, it was believed that an atom was a solid ball. Now, it is known that an atom is not solid and has separate parts to it. At its centre, there is a heavy *nucleus*. Around the nucleus, *electrons* whirl at tremendous speeds in much the same way that the planets revolve around the sun. Electrons are charges of electricity.

Nuclear energy

Sometimes, we speak of the "mighty atom" because, though an atom is small, its nucleus is held together by mighty forces which, when released, give a large amount of energy. This *nuclear energy* is used in some electricity power-stations and explosive missiles.

Matter and molecules

Scientists have another name for all materials, whether they be solids, liquids or gases. They call them *matter*.

Matter consists of *molecules*. A molecule is a group of atoms. An oxygen molecule contains 2 atoms; a mercury molecule contains 1 atom; a water molecule contains 2 atoms of hydrogen and 1 atom of oxygen. The spaces between molecules, even in solids, are much larger than the molecules themselves. Molecules are always moving, quickly and haphazardly.

The spaces between molecules

Pour water into a jar so that it is about three-quarters full. Use a piece of gummed paper to mark the level of the surface of the water. Stir some salt in the water. Add salt until no more will dissolve. There is no rise in the water level. The salt molecules have filled up the spaces between the water molecules.

The movement of molecules

Shake up a few dried peas in a sealed bottle. Suppose that the peas are molecules. Notice their haphazard movement.

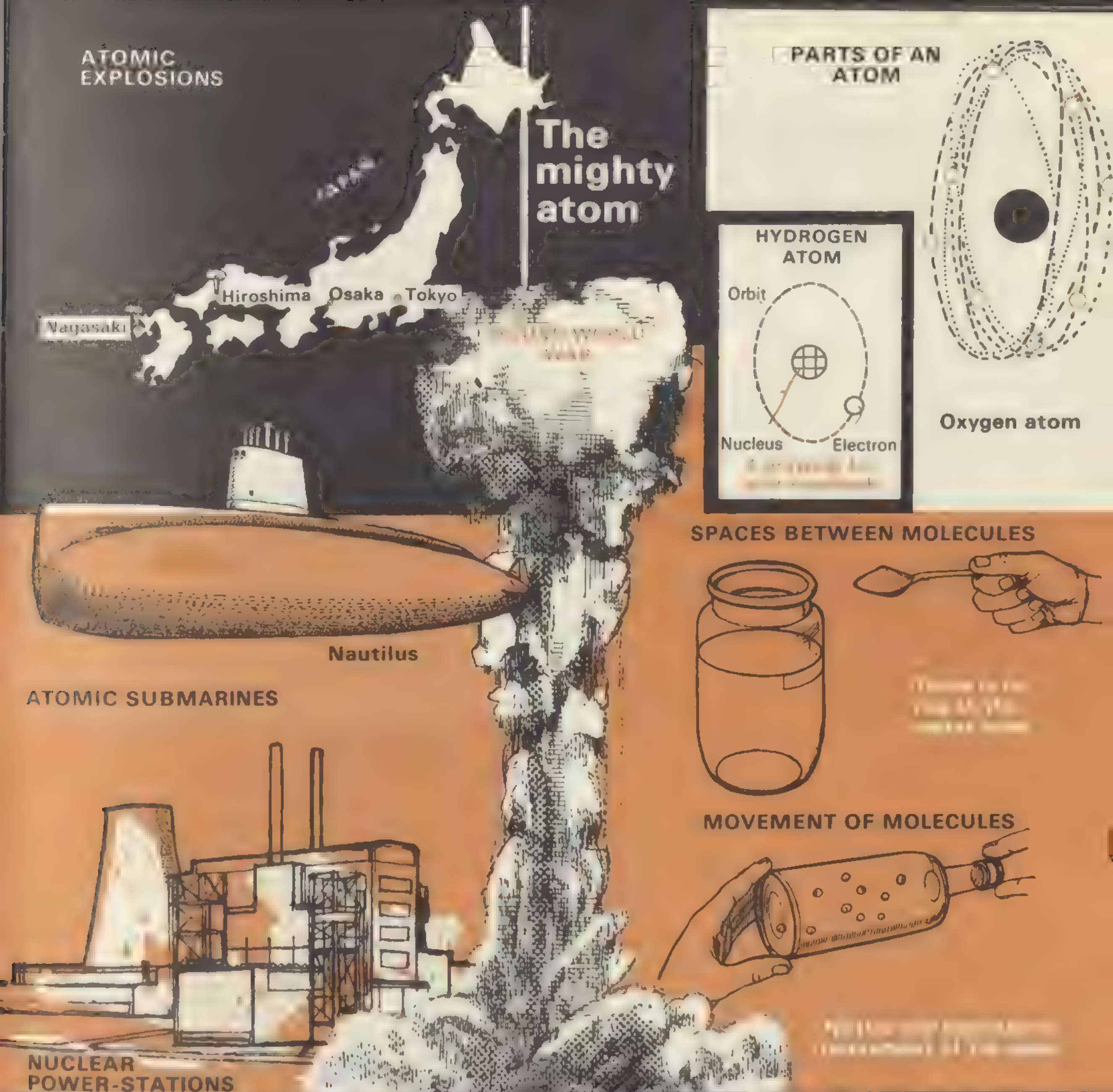
MORE THINGS TO DO

1. Copy the drawing shown in the black frame opposite.

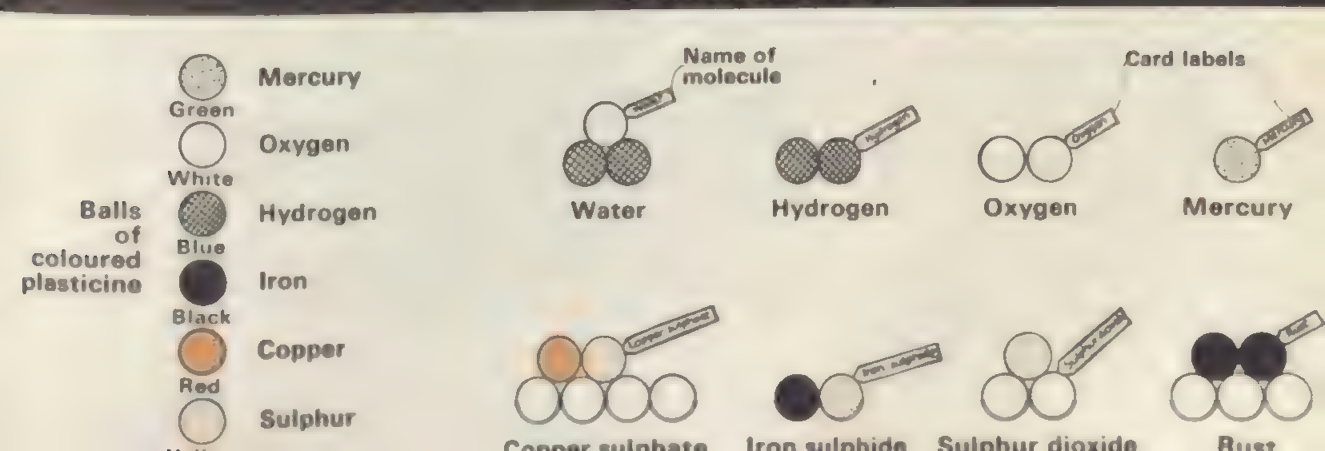
2. Write one sentence about each of these words in a way which shows that you know what the word means.

Atom; nucleus; electron; matter; molecule.

3. Make some plasticine "molecules" in the way shown opposite.



PLASTICINE "MOLECULES"



24 Two common elements

Two non-metals

Two common elements are carbon and sulphur. Both are *non-metals*.

For convenience, chemists have put all the elements into two groups – *metals* and *non-metals*. The differences between them are shown in a table opposite. There are many exceptions. Usually, metals are hard and solid, but lead is soft. Mercury is a liquid. *Graphite*, which is a form of carbon, is a non-metal but, like metals, it shines and conducts electricity.

Carbon

All living things contain carbon. Coal contains very much carbon. Coke and soot are fairly pure kinds of carbon.

There are three main forms of carbon – *charcoal*, *graphite* and *diamond*. They are the same but they do not look the same. Charcoal is black, dull and soft. Graphite is black, shiny and a little harder than charcoal. Diamond is transparent, shiny and very hard. If you want to know more about charcoal, you should read Chapter 13, Book Four.

Graphite

Graphite is mined in Ceylon. It is also made artificially from coke. Graphite is used as a lubricant for machinery, for making contacts in batteries and electrical machines, and, when mixed with clay, for making pencil "leads". Pencil "leads" are so named because, years ago, they were made of real lead.

Graphite conducts electricity

Make the electric circuit shown opposite. Use a short piece of pencil "lead" to connect the lamp bulb to the free end of the copper wire. The lamp lights. What does this show?

A real lead pencil

Rub a piece of lead on a sheet of white paper. You will make faint grey marks.

Diamonds

It is believed that diamonds have been formed by the enormous pressure of rocks on plant material in the earth's crust. Small diamonds can be made artificially. Diamonds are used as jewellery and for making cutting tools.

Sulphur

There are several different forms of sulphur. The best known form is the yellow powder that is called *flowers of sulphur*.

Sulphur is used in making medicines, gunpowder, paper, matches and *ebonite*. Ebonite is a mixture of sulphur and rubber.

Making plastic sulphur

Put some flowers of sulphur in a test-tube. Heat the test-tube. When the sulphur becomes a brown liquid, pour it into a dish of cold water. The sulphur cools rapidly and becomes soft and rubbery. Feel it. This is *plastic sulphur*. It will change into hard, solid, yellow sulphur if it is exposed to the air.

MORE THINGS TO DO

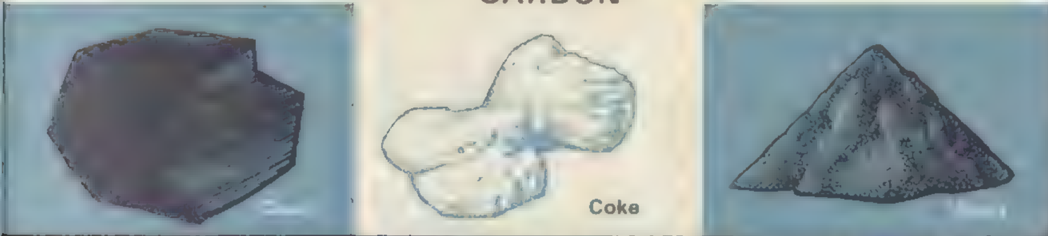
1. Copy the "**Metals and Non-Metals**" table shown opposite.

2. Write one sentence about each of these things.

Carbon; graphite; charcoal; diamond; mercury; sulphur; ebonite.

Two common elements

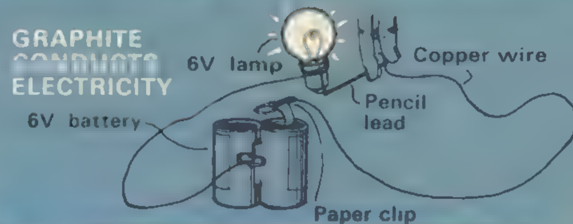
CARBON

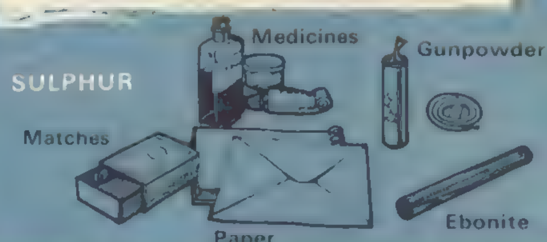


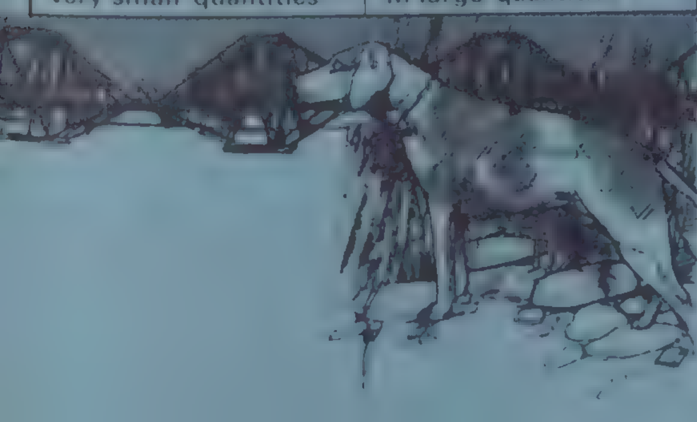
Coal contains much carbon — Coke and soot are fairly pure kinds of carbon

Charcoal, graphite and diamond are the three main kinds of carbon

METALS AND NON-METALS	
METALS	**NON-METALS**
Shiny	Dull
Solid	Often liquids or gases
Hard	Soft
Good conductors of heat	Poor conductors of heat
Good conductors of electricity	Poor conductors of electricity
Never transparent	Often transparent
Strong	Often brittle
Hard-wearing	Not hard-wearing
Heavy in weight	Light in weight
Do not melt easily	Melt easily
Found in living things in very small quantities	Found in living things in large quantities







MAKING PLASTIC SULPHUR

25 Iron and rusting

Iron

Iron is one of the most useful elements. It is a metal, of course. It is strong, hard-wearing and cheap. It can be beaten into shapes and drawn out into wires. It is a good conductor of electricity. But, iron has one great fault: it rusts very easily.

Rusting

No doubt, you have seen old bicycle frames, cans, biscuit tins, etc. that have been lying out in the open for some time. They are eaten away by rust.

Rust is a yellow-brown powder. It forms when iron joins up with oxygen from the atmosphere. But, this happens only when water is present. That is why iron rusts quicker in wet weather than it does in dry weather.

Chemists have another name for rust. They call it *iron oxide*.

Oxidation

Fuels, such as coke, coal, wood, etc., contain carbon. When they burn, the carbon in them joins up with oxygen to make carbon dioxide.

When magnesium burns, it joins up with oxygen to make *magnesium oxide*.

When animals breathe, they take in oxygen and give out carbon dioxide. The carbon in the food that they have eaten joins up with oxygen to make carbon dioxide.

The making of *oxides* is called *oxidation*.

Rusting is slow oxidation. Iron slowly joins up with oxygen to make iron oxide.

The conditions for rusting

Place a clean iron nail in each of four jars. Arrange for the conditions in the jars to be as they are shown opposite. The *calcium chloride* in the third jar is a *drying agent*; it will absorb all the moisture from the air in the jar. The water in the fourth jar is boiled to drive out all the air that is dissolved in it: the layer of olive oil helps to keep the water air-tight.

Look at the nails after a week. The nails in the first and second jars have rusted. The nails in the third and fourth jars have not rusted.

This experiment shows that iron will not rust unless both oxygen and water are present.

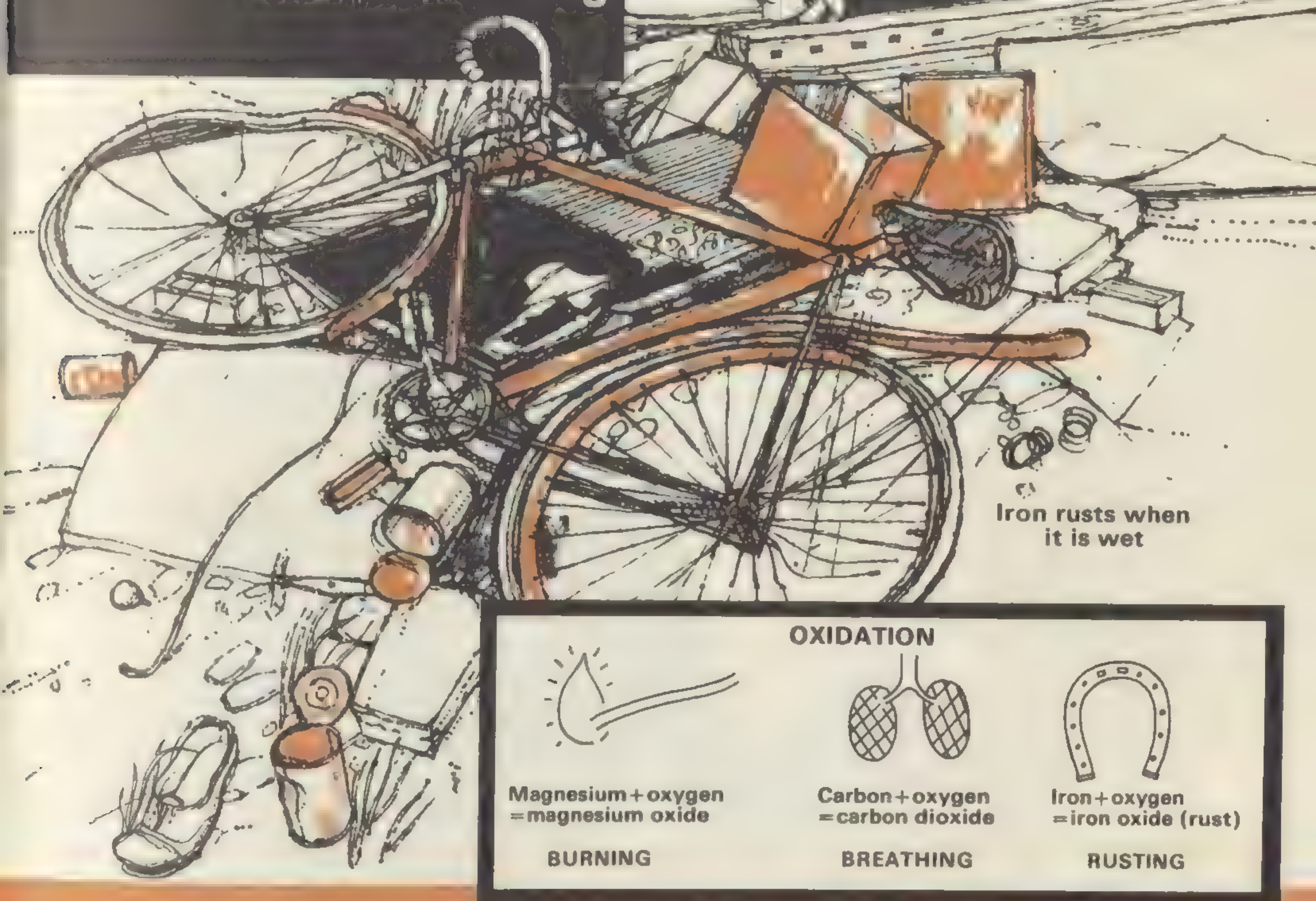
Rust prevention

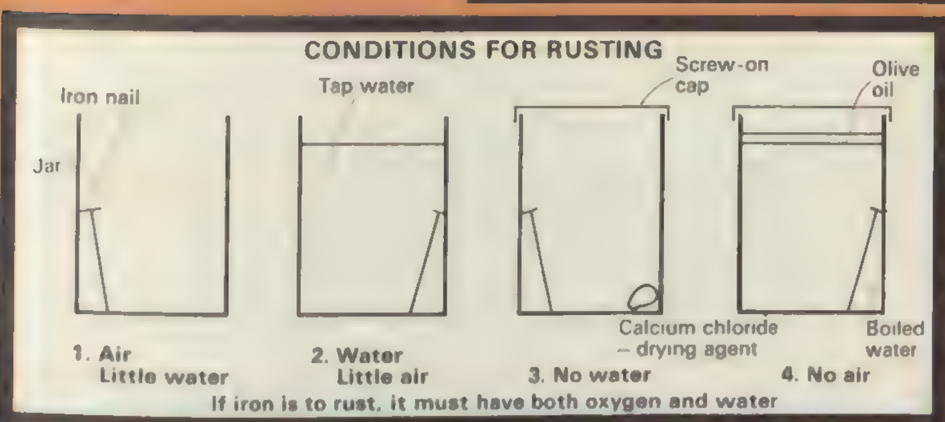
Rusting is prevented in several ways. *Stainless steel* contains the metal *chromium* which does not rust. "Tins" are wrongly named for they are not made of tin but *tinplate*, which is a thin sheet of iron that has been dipped into molten tin. The thin layer of tin does not allow air and water to reach the iron. Iron that is used for outdoor work is *galvanized* by dipping it in molten *zinc*. Zinc does not rust. Tools and machinery are often rubbed over with an oily cloth. The thin film of oil helps to keep out air and moisture. Paint is another protection against rust.

MORE THINGS TO DO

1. Copy the drawings shown in the black frames opposite.
2. Write a few sentences about rusting.
3. Copy the paragraph about rust prevention.

Iron and rusting





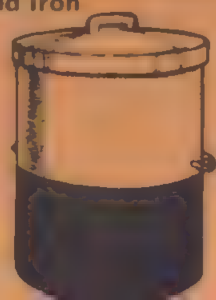
Paint

Oil

Stainless steel

Tinplate

Galvanized iron



RUST PREVENTION

26 Cosmetics

Looking beautiful

Most women want to look beautiful. A woman can improve her appearance with *cosmetics*. A cosmetic is a preparation that is used to beautify the skin or hair. Hair creams, shampoos, face creams, face powders, lipsticks, perfumes, hand lotions, toilet soaps, eyebrow pencils, etc., are cosmetics.

Cosmetics in Ancient Egypt

Cosmetics are not a modern idea. Women were using cosmetics thousands of years ago. A woman of Ancient Egypt had a dark skin and black hair. She whitened her hair and cheeks with a paste of chalk and water. Obviously, she thought that "gentlemen prefer blondes". She blackened her eyebrows with an eyebrow pencil that was simply a stick of charcoal.

An "eyebrow pencil"

Rub a stick of charcoal on the back of one of your hands. Notice how easily the charcoal makes a black mark on your skin. The charcoal sticks to the natural oil on your skin. Now, wash your hand.

Rouge

The red dye in some face powders and face creams is called *rouge*. It is obtained from a plant.

Jewellers' rouge is rust. Jewellers use it for polishing gold and other precious metals.

Polishing with rust

Use an old knife to scrape off the rust on a piece of rusty iron. Collect the rust in a small dish.

Dab a moist cloth in the rust and use it to polish a metal tap. The tap becomes bright and shiny because the rust is an abrasive.

Emulsions

Most cosmetic creams and lotions are emulsions. An emulsion is made by shaking oil and water together so that tiny drops of the oil become suspended in the water – or tiny drops of the water become suspended in the oil. Certain chemicals must be added to the emulsion, otherwise the oil and water will separate into two layers.

Making an emulsion

1. Pour some water and olive oil into a bottle. Then, shake the bottle quickly. The foamy mixture of olive oil and water is an emulsion. Let the bottle stand for a time. The mixture separates and the olive oil floats on the surface of the water. Does olive oil dissolve in water?

2. Now, put a teaspoonful of baking soda into the bottle. Again, shake the bottle quickly. Let the bottle stand for a time. The mixture does not separate. You have made a lasting emulsion.

MORE THINGS TO DO

1. Make a list of cosmetics.

2. Answer each of these questions with a full sentence.

(*a*) What is a cosmetic?

(*b*) How did the women of Ancient Egypt whiten their hair and cheeks?

(*c*) What is jewellers' rouge?

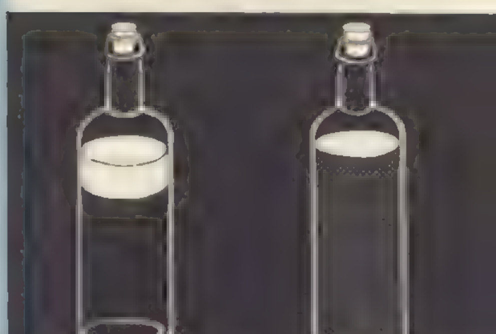
(*d*) What is an emulsion?

3. Collect a few wrappers from various cosmetic preparations. Paste the wrappers into your notebook.

Cosmetics

POLISHING WITH RUST

MAKING AN EMULSION



1. Olive oil and water
2. Olive oil, water

27 Noah's ark and sex

A Bible story

Do you know the story of Noah's Ark? It is in the Bible. In this story, God is grieved by the wickedness of mankind. He decides to send a great flood as a punishment. This flood will destroy all the people on the earth except Noah and his family whom God will spare.

God commands Noah to built a large wooden ark that will float safely on the flood waters. He also commands Noah to take two of each kind of animal aboard the ark. Of each kind of animal, one must be *female* and the other *male*, so that, when the flood is at an end, they will be able to multiply and so restock the earth with animals. If each of Noah's pairs of animals were of the same sex – both females or both males – they would not be able to multiply.

Sexual reproduction

When animals multiply, they make more of themselves. We say that they *reproduce*. "Reproduce" means "make copies".

Nearly all animals reproduce by making eggs which grow into young animals. This is called *sexual reproduction* because both sexes – the male and the female – take part in the making of the eggs.

A female animal has an *ovary* in which she produces *ova*. A male animal has a *testis* in which he produces *sperms*. Sperms are very tiny; they can only be seen under a microscope. A sperm looks like a tadpole. The wiggling of its tail enables it to move about in liquids. When a sperm enters an ovum, the ovum is fertilized. The *fertile* ovum will grow into a new animal. "Fertile" means "able to grow". A fertile ovum is an egg. An ovum that has not been fertilized will not grow into a new animal.

The life-history of a fowl

The stages in the life-history of a fowl are shown on the page opposite.

Mating

Ova are fertilized when animals *mate*. When fishes mate, the female fish lays her ova in the water. Then, the male fish sheds his sperms over the ova. The sperms join up with the ova and the eggs are formed.

The sex signs

Scientists use two simple signs as a kind of shorthand for writing "male" and "female". They are shown opposite. They can be seen on cages at the zoo.

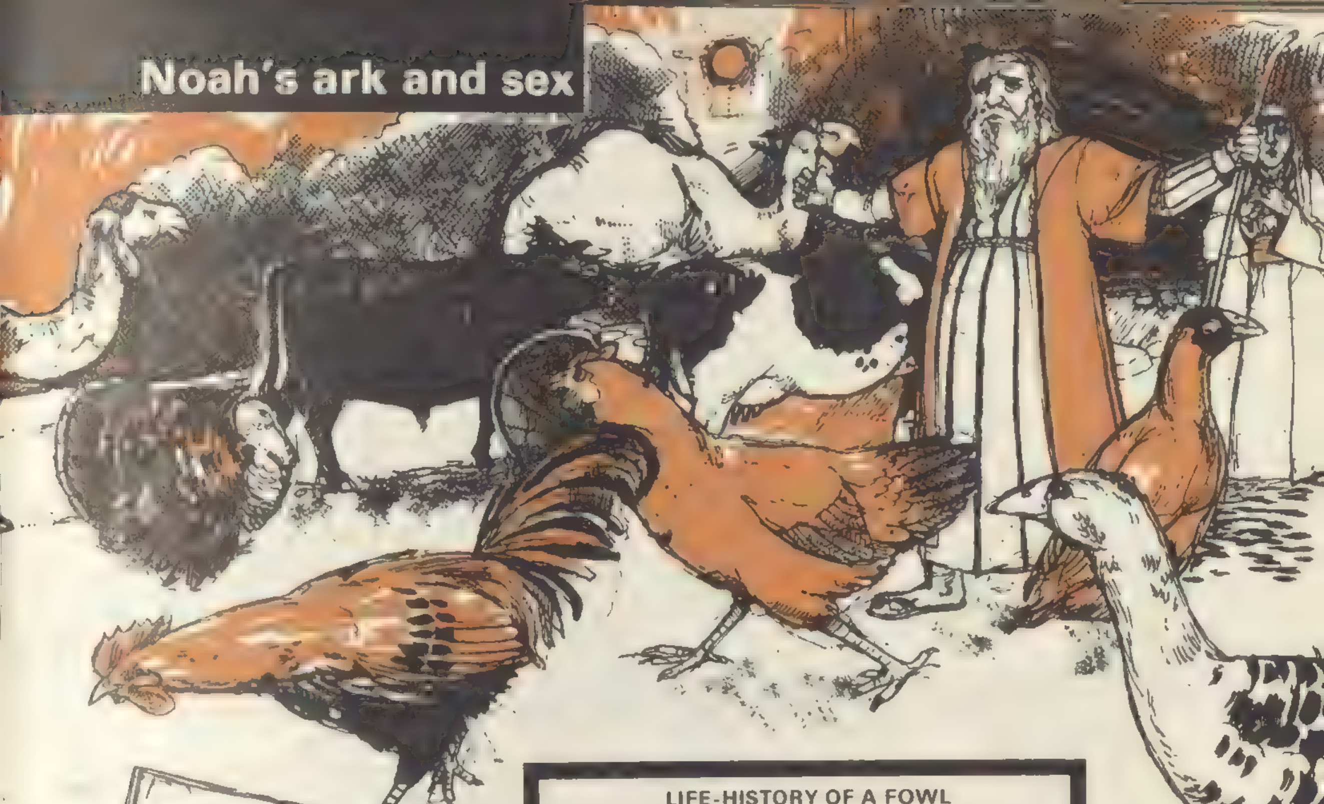
Asexual reproduction

Some very tiny animals can reproduce without sex. The *amoeba*, which, under a microscope, looks like an irregular-shaped piece of jelly, is neither male nor female. It grows larger and then divides to form two new animals. This is called *asexual reproduction*. "Asexual" means "without sex".

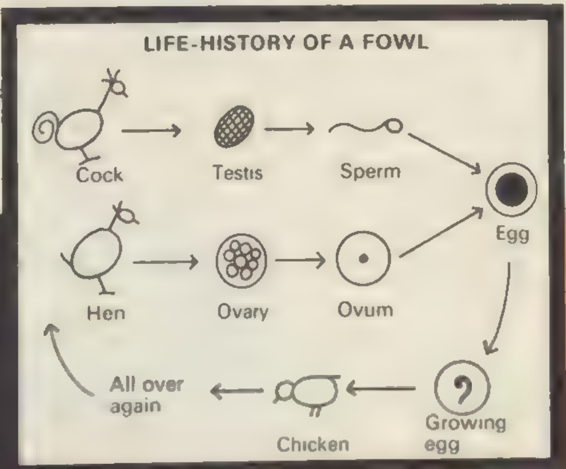
MORE THINGS TO DO

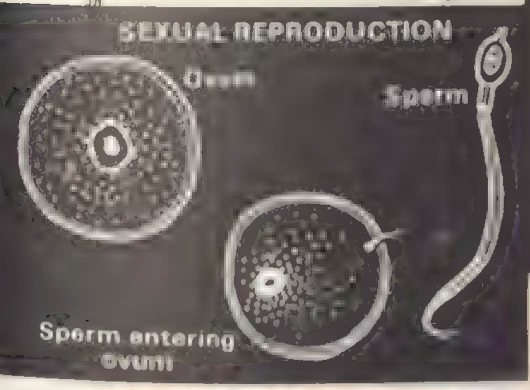
1. Copy the drawing shown in the black frame opposite.
2. Draw the sex signs. Label them.
3. Write a few sentences about asexual reproduction.
4. Find the story of Noah's Ark in the Bible. It is in the Book of Genesis, Chapters 6, 7, 8 and 9. Read the story.

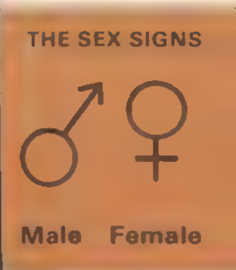
Noah's ark and sex



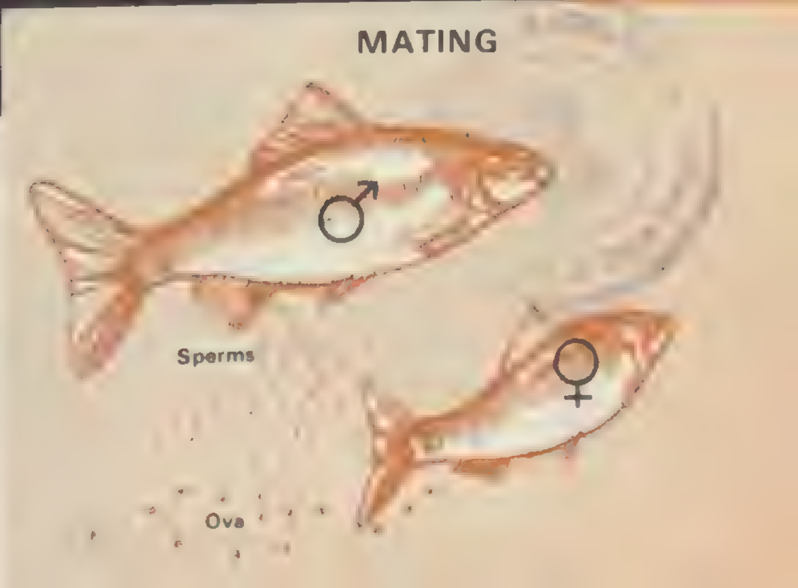
God says to Noah,
'And of every living thing of all flesh, two of every sort shalt thou bring into the ark to keep them alive with thee: they shall be male and female.'







ASEXUAL REPRODUCTION



28 Eggs

The beginning of life

Some very simple animals, like the amoeba, reproduce by dividing. But, most animals reproduce by making eggs which grow into new animals. All flowering plants reproduce by making seeds which grow into new plants. Eggs and seeds are the beginning of life.

How an egg grows

An egg has two main parts – the *germ* and the *yolk*. The germ is the living part of the egg. The yolk is food.

When an egg grows, the germ divides first into 2 parts, then into 4 parts, then into 8 parts, and so on. Eventually, there are millions of parts which separate into tissues and organs - heart, nerves, stomach, etc. The developing animal is called the *embryo*. It feeds on the yolk.

The stages in the growth of a frog's embryo are shown opposite.

Hatching trout

Hatch some trout eggs. (*Teacher*: trout eggs can be purchased from biological suppliers.)

Keep the eggs in moving water that is well aerated. Use the equipment shown opposite. The muslin keeps the eggs in the jar but allows the water to overflow.

Examine the baby trout under a magnifying glass. A baby trout is called an *alevin*. Look for these things.

Colour of eggs; eyes; alevin struggling out of shell; beating of heart; blood vessels; *yolk-sac*; gills; tail; loss of yolk-sac; growth of fins.

A hen's egg

The parts of a hen's egg are shown opposite.

The *shell* protects the soft contents of the egg. The germ grows and becomes the embryo chick. It feeds on the yolk. After about 20 days, very little yolk is left. The embryo breathes through the shell and the *skin*; both are porous.

The *white* does not become the feathers of the chicken, as some people think. It protects the yolk and dries up as the embryo grows. The white contains two *balancers* that hold the yolk in place. No matter how the egg is moved, the yolk always remains in the same position so that the germ is always uppermost and near to the heat of the hen.

The young chick fills its lungs with the air in the *air space* before it breaks open the shell and is hatched.

Looking at a hen's egg

Crack the shell of an egg and drop its contents into a dish. Look for the parts mentioned above.

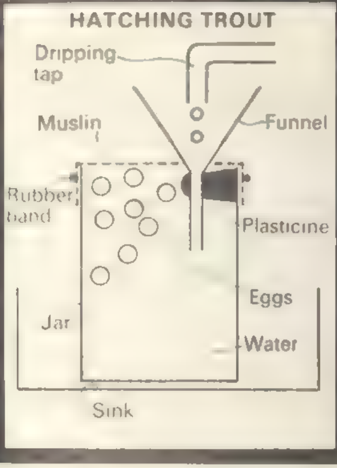
The eggs of mammals

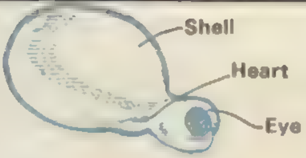
The eggs of mammals are much smaller than those of other animals. They have no shells and contain little or no yolk. A mammal embryo grows within the body of its mother and obtains its food from her bloodstream.

MORE THINGS TO DO

1. Copy the drawings shown in the black frames opposite.
2. Draw an alevin with a yolk-sac. Label it.
3. Write a few sentences about an embryo.

HATCHING TROUT



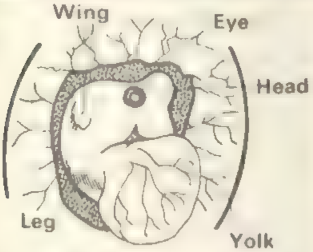


1. Alevin leaving shell

2. Alevin with yolk-sac

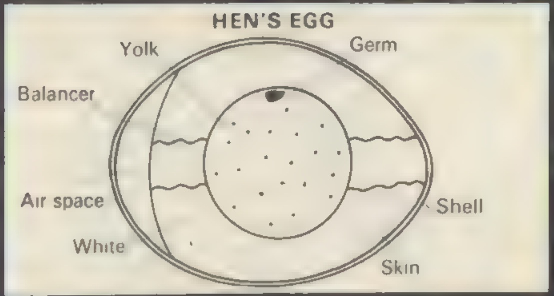
3. Alevin losing yolk-sac

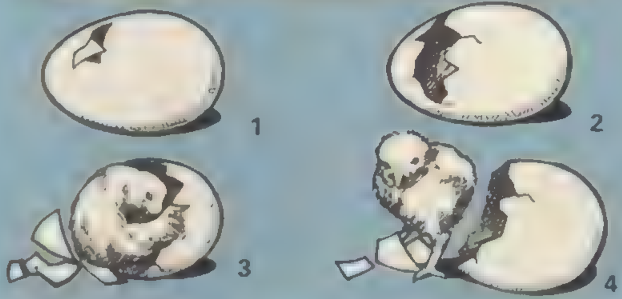
Eggs



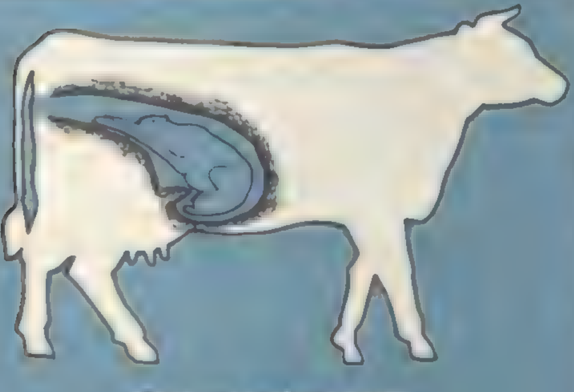
Embryo chick after 4 days

Embryo chicken after 20 days



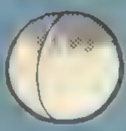


Hatching of a chick



A human egg is smaller than a full stop

HOW A FROG'S EGG GROWS



1. Two parts

2. Four parts

3. Eight parts

4. Small black parts and large yolk parts

5. After more division

6. Black parts grow around yolk

7 Growth of nervous system (groove)

8 Gills

9 Eyes, mouth and tail

29 The birth of a baby

A great event

We think that the birth of a human baby is a great event. Certainly, it is a great event for the mother and father of the baby. In caring lovingly for the baby, they will find much happiness.

But, really, the birth of a baby is an event that is both ordinary and natural. Very many babies are born every day.

Reproduction in mammals

A mammal reproduces by making eggs, but, unlike other animals, it does not lay its eggs. The eggs are fertilized and grown inside the body of the mother mammal.

Humans reproduce in the same way as do other mammals. You will learn about the birth of a human baby, if you find out what happens before and during the birth of a baby rabbit.

Sexual organs

Some of the drawings on the page opposite show the *sexual organs* of rabbits and humans. The rabbit's organs are drawn so that you can see the important parts that are inside them.

Mating

When rabbits mate, the male rabbit pushes his *penis* into the *vulva* of the female rabbit. Millions of *sperms* leave the *testes* of the male rabbit and pass along the *sperm-tubes* into the *urethra* from which they are squirted into the *vagina* of the female rabbit. Most of the sperms die, but some fertilize the ova in the *ovary-tubes*. Though many ova are fertilized, it is rare for more than eight of them to develop into baby rabbits.

Growth of the embryos

The eggs pass into the *womb* where they grow into embryos. They become fixed to the wall of the *womb*. A rabbit's embryo is shown opposite. Food and oxygen from the bloodstream of the mother rabbit pass through the *umbilical cord* into the embryo.

Birth

After about a month, the embryos are fully grown and ready to be born. Muscles in the womb and the vagina push the baby rabbits through the vulva out into the world. The mother rabbit chews through the umbilical cord. The remains of this cord, which are on the baby rabbit's abdomen, are called the *umbilicus*.

Your "belly button" is your umbilicus. It is the place where you were attached to your mother before you were born. Your umbilical cord was cut by a doctor or a midwife.

Pregnancy periods

The time between mating and birth is called the *pregnancy period*. The pregnancy periods for different mammals are shown opposite.

Milk

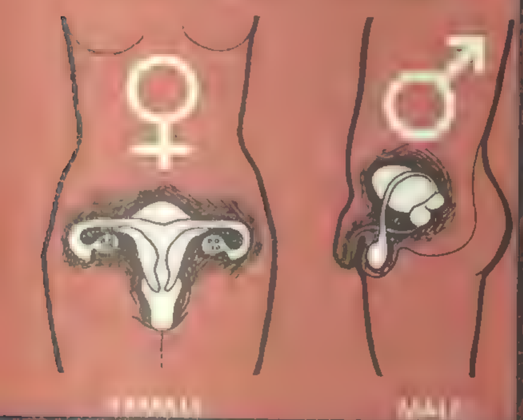
New born mammals are weak and defenceless. Until they are strong, they feed on milk from the *teats* of the mother mammal.

MORE THINGS TO DO

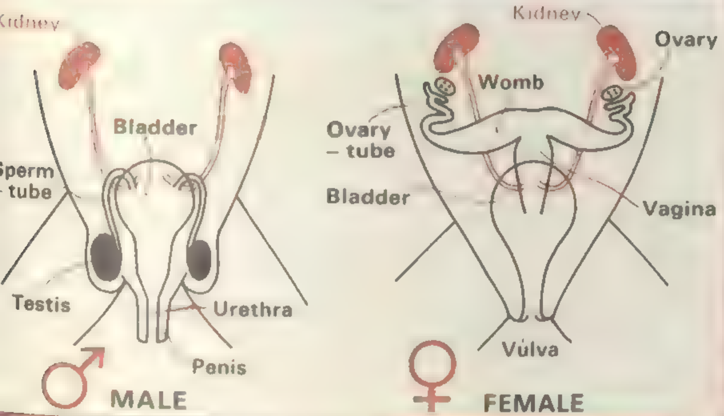
1. Draw a human embryo. Label it.
2. Write a short essay with the title *Reproduction in Rabbits*.

The birth of a baby

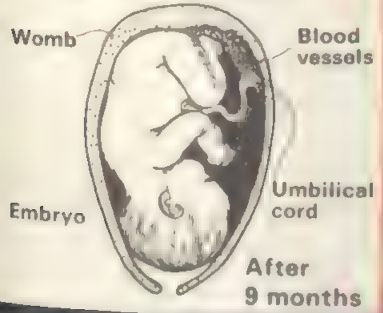
HUMAN SEXUAL ORGANS



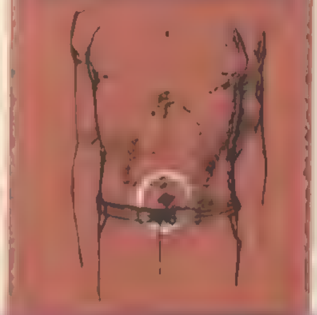
SEXUAL ORGANS OF THE RABBIT



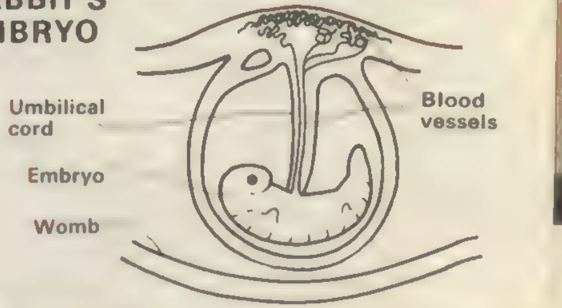
HUMAN EMBRYO



HUMAN UMBILICUS

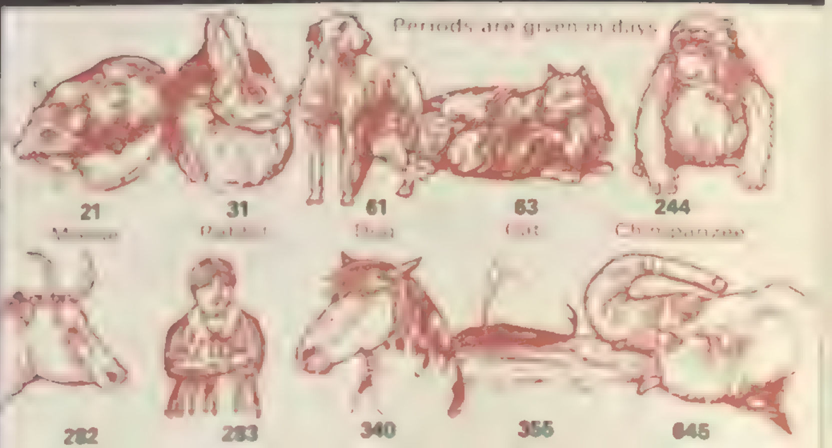


RABBIT'S EMBRYO



MILK

PREGNANCY PERIODS



30 The salmon and the eel

The salmon

The salmon is a large fish. When it is full-grown, it weighs as much as 20 kilogrammes.

Full-grown salmon live in the sea, but, to breed, they swim up rivers into fresh water. They do this in the spring. They travel for many miles, leaping over waterfalls and other obstacles. During the summer and autumn months, they reach small streams. The salmon are weakened and exhausted by their long journey.

The salmon breed in mid-winter. The female salmon scoops a hollow in the gravel on the bed of a stream and lays her eggs in it. The eggs are fertilized by the male. Then, the older salmon die. The younger and stronger ones return to the sea.

The eggs hatch at the end of the winter.

During the following summer, the young fish, or *fry*, as they are called, feed and grow.

The young salmon live in the streams and rivers for about two years, and then, in the spring of the third year, they swim down to the sea where they remain for a few years.

The eel

The eel could be mistaken for a snake. Its body is long, narrow, round, smooth and slimy. But, if you look closely at an eel, you will see that it is a fish. It has *fins* and *gills*. Its tail and tail-fin are very long.

Eels live in fresh water in ponds, rivers, streams and even drain pipes on the west coast of Europe and the east coast of North America.

When the eels are about nine years old, they are ready to breed. They change colour from grey-brown to silver. Then, in the autumn, they swim down to the sea and begin a long journey to the *Sargasso Sea* in the Atlantic Ocean.

The eels arrive at the Sargasso Sea in the following spring and summer. They breed at the bottom of the sea. Then they die.

The eggs hatch to give baby eels which do not look like grown-up eels. They are tiny, flat and almost transparent.

The baby eels swim to either North America or Europe. The journey to Europe takes about three years. During the journey, the baby eels change into young eels which are round in shape. Young eels are called *elvers*.

Looking at an eel

Perhaps your teacher has an eel, either living or preserved, that he will allow you to examine.

Look for the fins and the gills.

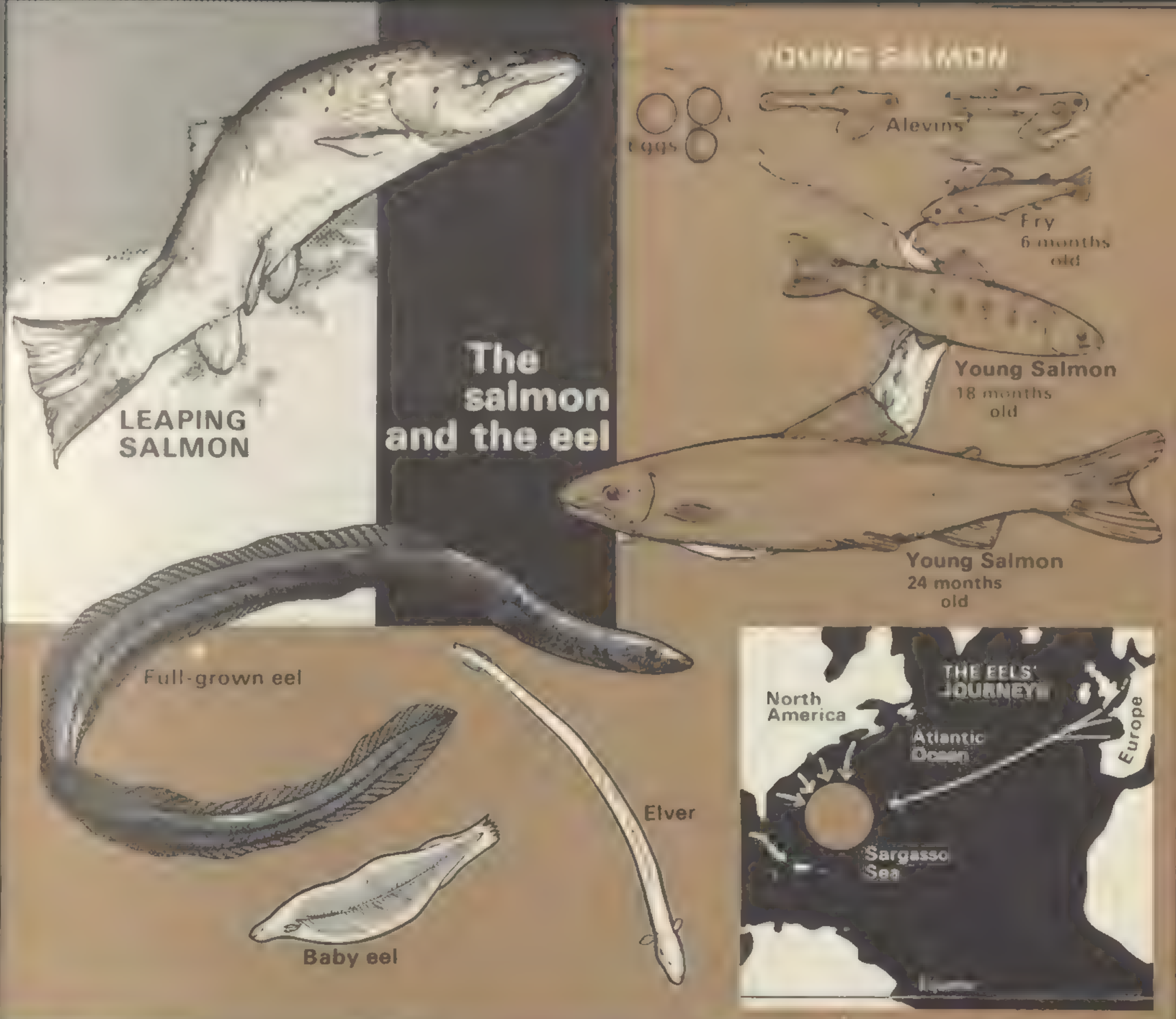
Fish are food

The salmon and the eel provide us with food. Some other common sea-fish that provide us with food are shown opposite.

MORE THINGS TO DO

1. Draw a leaping salmon, an adult eel and a baby eel.
2. Write a few sentences about *either* the salmon *or* the eel.
3. Make a list of sea-fish that provide us with food.
4. Find out what you can about *jellied eels*, *smoked salmon*, *kippers* and *bloaters*.

The salmon and the eel



FISH FOR FOOD

31 The "little wanderer"

The garden snail

The garden snail could be called the "little wanderer" because, during the warm months of the year, it spends most of its time wandering about the garden and feeding on plants. The garden snail moves very slowly.

Have you seen the slimy glistening track of a garden snail? It makes this track on hard ground to protect the tender underside of its body.

The garden snail is most active at night. In the day, it hides under a stone or in a hole in a wall or the ground.

The "little wanderer" hibernates during the winter. To do this, it finds a suitable place such as an ivy-covered wall, the corner of a shed, a hole in a rockery, etc. It closes the entrance of its shell with a tough skin.

Looking at a garden snail

Examine a living garden snail. Notice the colour and the shape of its shell.

Place the snail on a sheet of glass. Watch a snail as it crawls along. The part of the snail that makes contact with the ground is called the "foot". Can you see a slime track? Notice that the snail has four feelers. They are sometimes called "horns". There is a small knob on the tip of each of the two large feelers. These knobs are sensitive to light. They are the "eyes" of the snail.

Look at the underside of the snail through the glass. Can you see its mouth?

Place the snail in a jar of warm water. Seal the jar and let it stand overnight. The snail will die slowly but painlessly from lack of oxygen and, what is more, it will come out of its shell. Look at the dead snail. Notice that its skin is grey in colour and covered with wart-like lumps. Look for the breathing hole.

Put a garden snail in a dry jar. Then, seal the jar. Examine the snail after a few days. There will be a skin over the entrance to its shell.

How snails breed

Most kinds of snails have both male and female sexual organs. There are no separate male and female snails. Each snail makes both ova and sperms, but the ova of one snail are fertilized by the sperms from another snail.

Molluscs

The garden snail belongs to a family of animals that are called *molluscs*. A mollusc has no backbone. Its body is soft and simple. Most molluscs have shells, but some, like the octopus and the slug, do not have shells.

Some molluscs are shown opposite.

MORE THINGS TO DO

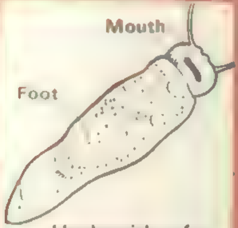
1. Draw a garden snail. An easy way to do this is shown opposite.
2. Write a few sentences about the garden snail.
3. Make a list of molluscs.
4. Make a collection of mollusc shells in the way shown opposite. You can do this at home.

Garden snail feeds on plants

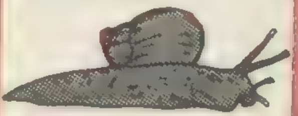
Garden snail making a slime track

Parts of a garden snail

LOOKING AT A GARDEN SNAIL



Underside of a garden snail



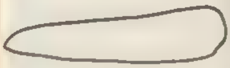
Side view of a garden snail

Front view of a garden snail

Hibernating snail

The "little wanderer"

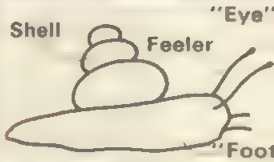
DRAWING A GARDEN SNAIL



1. "Foot"

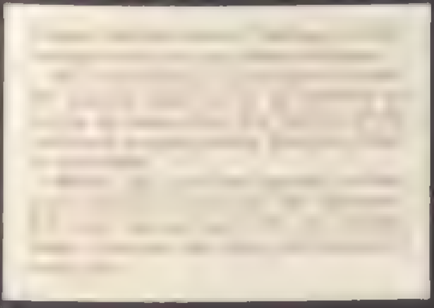
2. Shell

3. Feelers

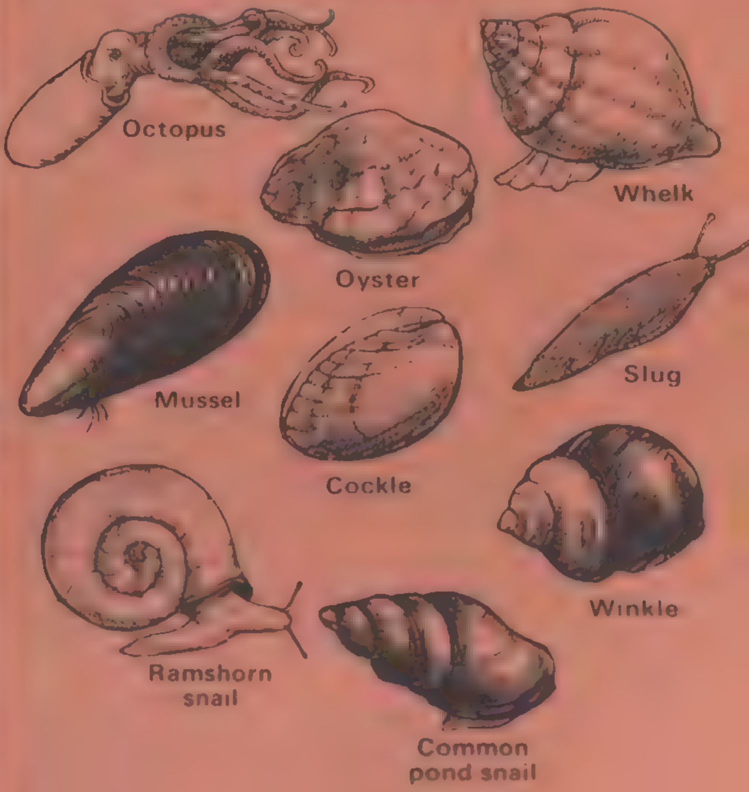


4. Labels

COLLECTING MOLLUSC SHELLS



MOLLUSCS



32 Four insect pests

Insect pests

Many insects are pests because they either carry diseases or eat our food plants. In what way is the cabbage white butterfly a serious pest?

Four important insect pests are: the *locust*, the *tsetse* fly, the *mosquito* and the *house-fly*. The locust damages crops. The tsetse fly, the mosquito and the house-fly carry diseases.

Vectors

Animals that carry diseases are called *vectors*. Tsetse flies, mosquitoes, house-flies, blowflies, fleas, rats and mice are vectors. Can you think of any other vectors?

Town and city councils employ "rat-catchers" to destroy rats. This helps to prevent diseases.

The locust

The locust is a large kind of grasshopper. It lives in the warm lands, like Africa and India. It breeds very quickly and eats enormous quantities of vegetation. A swarm of locusts will completely strip fields of their crops within a few hours.

The tsetse fly

The tsetse fly lives in the hot parts of Africa. It sucks the blood of such animals as cattle, antelopes and humans, and, in so doing, it carries *sleeping sickness* from one animal to another.

The mosquito

The mosquito is a kind of *gnat*. It lives in the swamps of warm countries, like Italy and India. The female mosquito feeds by sucking the blood of humans. In this way, it carries the disease *malaria* from one person to another. Malaria can cause death. The male mosquito feeds on plant juices. It is quite harmless.

Preventing malaria

Malaria is prevented in *five* main ways that are explained on the page opposite.

The house-fly

The house-fly is a common enough insect. It breeds very quickly in warm weather. It lays its eggs in decaying materials in rubbish heaps, dustbins, etc. and, as it does this, it accidentally picks up disease-bacteria with its feet. When it settles on plates, dishes, cutlery, etc. the bacteria fall on to food. These bacteria can make people ill.

Looking at a house-fly

Use a suitable insecticide spray to kill some house-flies.

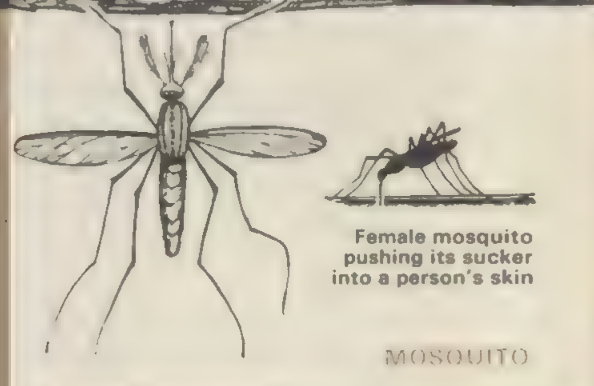
Look at one of the dead house-flies through a magnifying glass. Can you see the head, chest and belly? Can you see the compound eyes? Count the legs. Is the house-fly an insect?

MORE THINGS TO DO

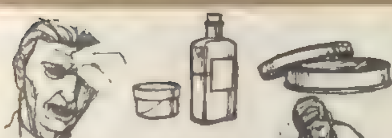
1. Use tracing paper to copy the drawings of insect pests shown opposite. Below each insect, print its name.
2. Write two sentences about each of these topics.

   Vectors; locusts; sleeping sickness; malaria; house-fly; male mosquito.
3. Write a short essay with the title *Preventing Malaria*.
4. Use an encyclopedia to find out what you can about (*a*) malaria and (*b*) the *Colorado beetle*.

Four insect pests



PREVENTING MALARIA

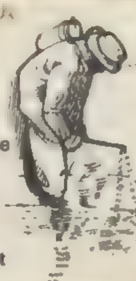


1. Persons with malaria are given such medicines as quinine, mepacrine and paludrine.

2. Smelly ointments that mosquitoes do not like are rubbed on the skin.

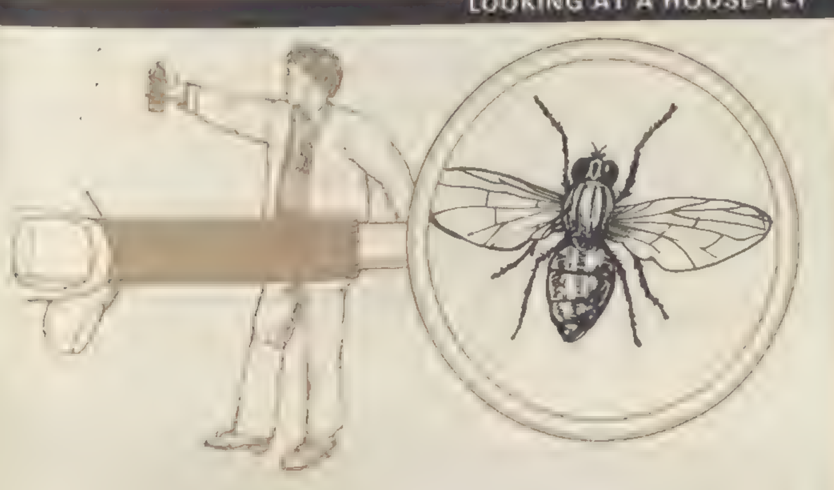
3. In tropical countries, people cover their beds with nets that mosquitoes cannot enter.

4. The breeding grounds are sprayed with insecticides that kill the mosquitoes.



5. Oil is sprayed on swamps. The breathing tubes of the mosquito "grubs" become clogged with oil and they die from lack of oxygen.

LOOKING AT A HOUSE-FLY



33 The work of flowers

The parts of a flower

A flower has four main parts – *petals, sepals, stamens* and the *pistil*.

The petals are usually coloured. They attract insects which visit flowers in search of *nectar*, a sweet, sugary liquid that is contained in *nectaries* at the bottom of the petals.

The sepals are green leaves. They protect the flower when it is a bud.

The stamens are the male organs. A stamen has two parts – the *filament* and the *anther*.

The pistil is the female organ. It has three parts – the *stigma*, the *style* and the *ovary*.

Pollination

The first stage in the making of seeds is called *pollination*.

When an anther is ripe, it bursts open and releases *pollen grains*. Pollen grains are yellow. The pollen grains fall on stigmas. A stigma is covered with a sticky, sugary liquid that easily holds the pollen grains.

If the pollen grains fall from the anthers on to the stigma in the same flower, it is *self-pollinated*. Chick-weed is self-pollinated.

If the pollen grains fall from the anthers of one flower on to the stigma of another flower, it is *cross-pollinated*. The buttercup is cross-pollinated.

Cross-pollination

Flowers are cross-pollinated by wind, water and insects. Cross-pollination is explained opposite.

Fertilization

The second stage in the making of seeds is called *fertilization*.

The pollen grains on the stigma feed on the sugary liquid. They make tubes which grow down the style into the ovary where each tube joins up with an *ovule* to form a seed.

After the ovules have been fertilized, the petals and the sepals wither and the walls of the ovary grow thicker to form a fruit. The fruit protects the seeds.

Male and female flowers

Some plants, such as the hazel and the oak, have separate male and female flowers. Pollination occurs when the male flowers shed pollen grains on to the stigmas of the female flowers. The male flowers of the hazel are called *catkins*.

Looking at a buttercup flower

Examine a buttercup flower. How many petals and sepals are there? What is the colour of the petals?

Look at the stamens and the pistil through a magnifying glass.

Notice that the pistil is divided into separate parts. They are called *carpels*. Each carpel has a stigma and an ovary. Can you see the anthers, the pollen grains and the stigmas?

The life-history of a flowering plant

The stages in the life-history of a flowering plant are shown opposite.

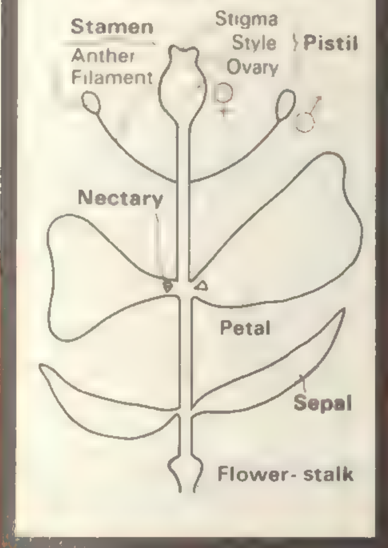
MORE THINGS TO DO

1. Copy the drawings shown in the black frames opposite.

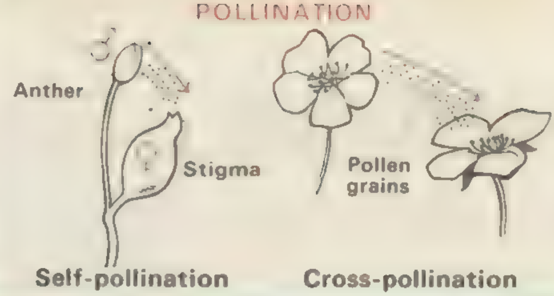
2. Write a few sentences about cross-pollination.

The work of flowers

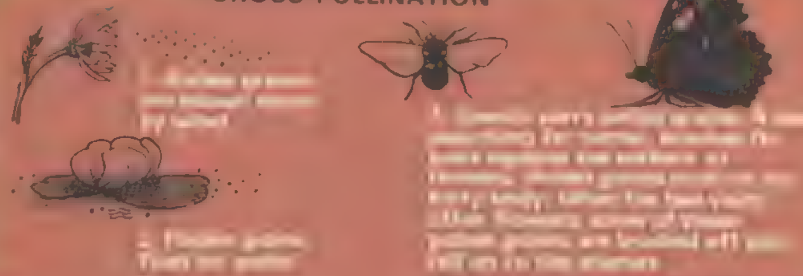
PARTS OF A FLOWER



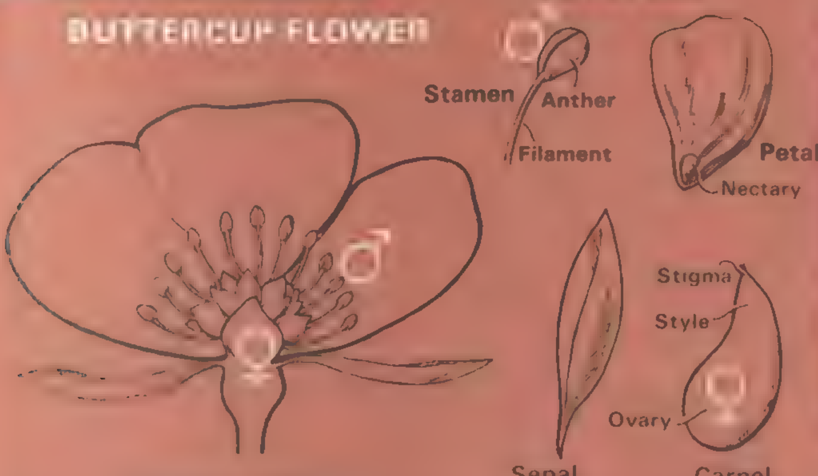
POLLINATION



CROSS-POLLINATION

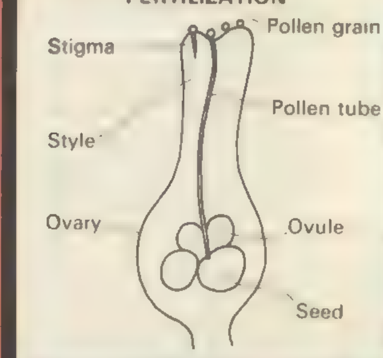


BUTTERCUP FLOWER

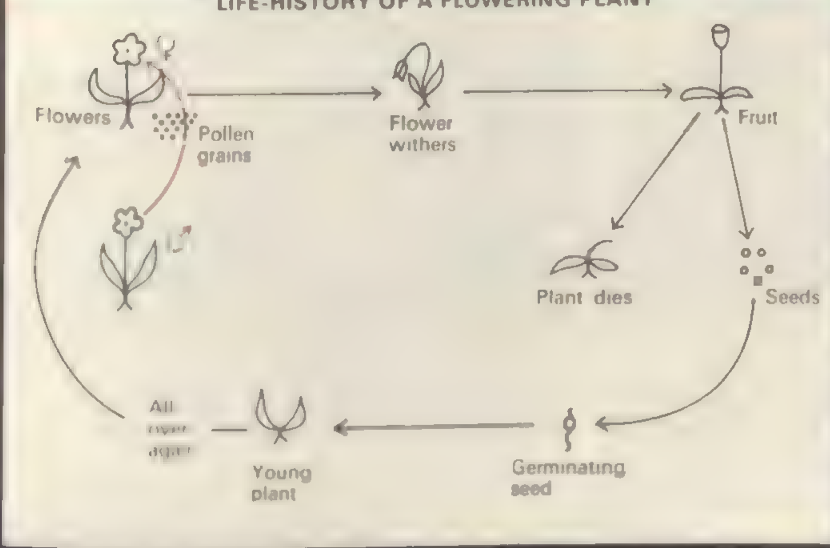


Section of flower

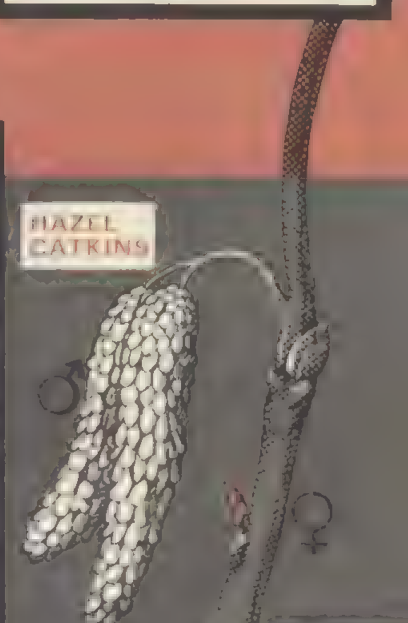
FERTILIZATION



LIFE-HISTORY OF A FLOWERING PLANT



HAZEL CATKINS



Male flowers shed pollen grains on the female flowers

34 The mushroom

Plants without flowers

Some plants, like the *ferns*, *mosses*, *fungi* and *seaweeds*, do not have flowers. These plants without flowers cannot reproduce by making seeds. Most of them reproduce by making *spores*. The spores grow into new plants.

The mushroom

The mushroom is a fungus. It is a good example of a plant that begins its life as a spore.

The mushroom plant grows below the surface of the soil. It is a mass of white threads that grow and spread out in all directions. The threads take in water and food. The food of the mushroom plant is mineral salts and decaying plant material, such as horse manure, hay, straw, etc.

A part of the mushroom plant grows above the ground. This is what people call a mushroom. Really, it is only the "fruiting body" of the mushroom plant. It is called the "fruiting body" because it makes the spores which will grow into new mushroom plants.

The "fruiting body" has two parts – a stout *stalk* and an umbrella-shaped cap. On the underside of the cap, there are delicate, dark-brown "*gills*" that produce millions of spores. Around the stalk, there is a ring of skin which is the place where the cap was once joined to the stalk.

How a mushroom grows

A mushroom plant begins its life as a spore. The spore grows to become the mass of tangled threads that is a mushroom plant. Some of the threads grow above the soil. Their ends swell to form young "fruiting bodies". These are called "button mushrooms". The cap of a "button mushroom" is attached to the stalk. Later on, the cap opens and breaks away from the stalk.

A young "fruiting body" has pink "gills". An old "fruiting body" has dark-brown "gills".

Looking at a mushroom

Examine a mushroom. What is its colour? What is its shape? Look for the cap, the "gills", the stalk and the ragged ring of skin around the stalk.

Making a spore-print

Take off the cap of a mushroom. Place the cap, "gills" downwards, on a sheet of paper. Use a pin to fix the cap to the paper. After a few days, remove the cap. There will be a ring of black spores on the paper.

Edible fungi

Mushrooms are edible fungi. "Edible" means "good to eat". No doubt, you have eaten mushrooms. Other edible fungi are shown opposite.

Poisonous fungi

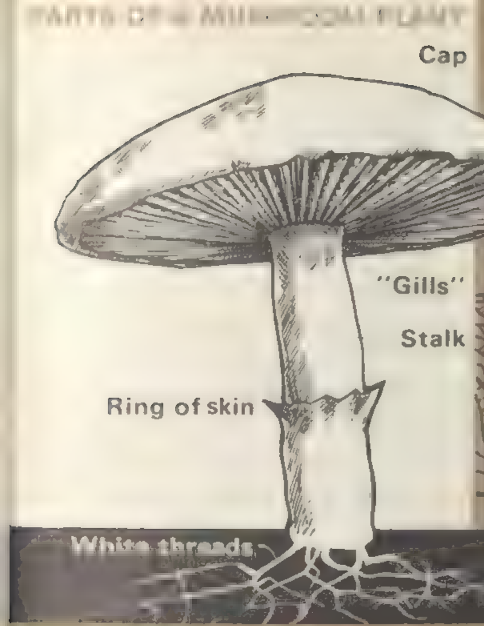
You must be careful with fungi because many of them are poisonous. Some poisonous fungi are shown opposite.

MORE THINGS TO DO

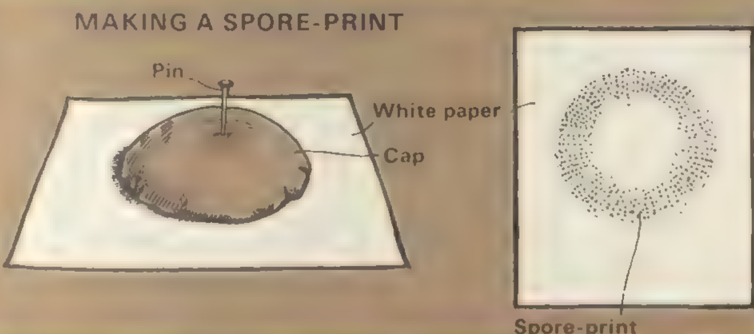
1. Draw a mushroom. An easy way to do this is shown opposite.
2. Copy these words.

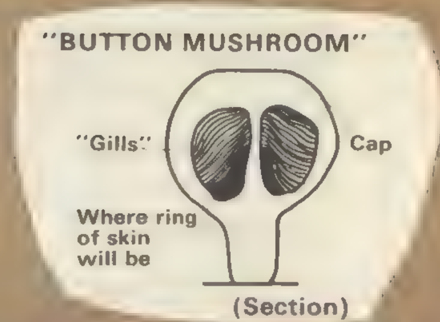
Fungi

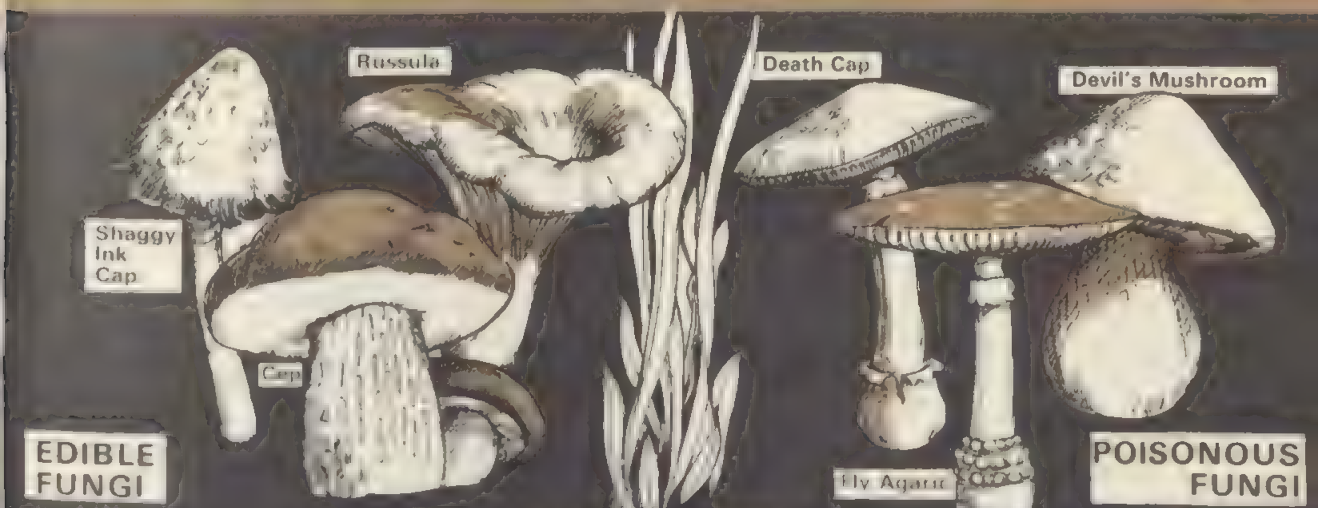
Mushroom; spore; "fruiting body"; cap; "gills"; stalk; edible; toadstool.



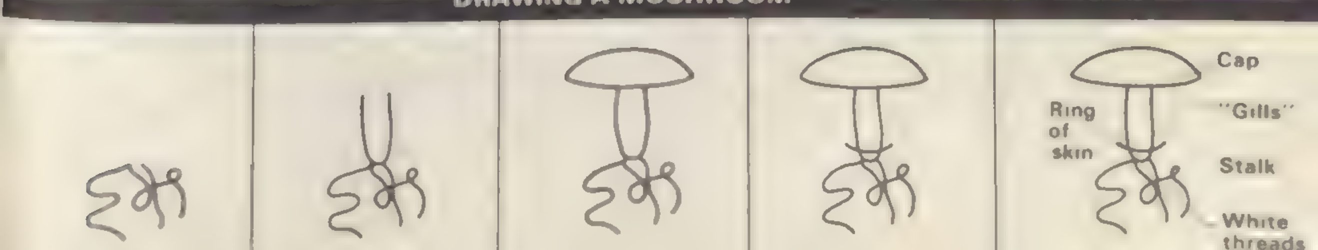
The mushroom







DRAWING A MUSHROOM



35 Bread and wine

Yeast

Have you heard of *yeast*? It is a very tiny plant that can only be seen under a microscope. It is used in the making of bread and wine. You may be able to buy a lump of yeast at a baker's shop. A small lump contains millions of yeast plants.

Yeast is a fungus. It feeds on sugar and, as waste, gives off carbon dioxide and *alcohol*. Alcohol is a liquid. There is alcohol in wine and beer. It is alcohol that causes *intoxication*.

The yeast plant reproduces in a special way that is called *budding*. When a yeast plant becomes large, it grows a *bud*. Then, the bud breaks away from the parent plant and grows into a new yeast plant. If a yeast plant grows quickly, it produces many buds. Small buds grow out of the large buds.

Growing yeast

Put a tablespoonful of sugar and a small pinch of yeast into a jar that is half full of warm water. The temperature of the water should be between 15°C and 25°C. Check this with a thermometer. Stir the water so that the sugar dissolves.

After a few hours, lower a piece of burning paper into the jar. The paper is extinguished immediately. Why?

Use one of your fingers to smear some of the liquid from the jar on to a microscope slide. Place the slide under a microscope and examine the growing yeast. Perhaps your teacher will help you with this. Can you see the buds?

A model yeast plant

Make a plasticine model of a budding yeast plant in the way shown opposite.

Bread

Bakers put yeast in *dough*. The yeast feeds on the sugar in the dough and gives off carbon dioxide. The dough becomes filled with tiny bubbles of carbon dioxide. This gas expands when the dough is baked; the bread "rises" and becomes spongy. Bread that contains yeast is called *leavened* bread. *Unleavened* bread contains no yeast; it is flat and hard.

Wine

Wine is made from sugar, yeast, water and fruit or vegetables. The sugar, yeast and fruit or vegetables are mixed together in warm water and then allowed to stand. The yeast feeds on the sugar and gives off alcohol and carbon dioxide. We say that the wine *ferments*. If the wine is bottled before fermentation has finished, the carbon dioxide gas dissolves in the wine. The wine sparkles and fizzes when the bottles are opened. Fruit and vegetables give wines their flavours.

Beer

Beer is made from yeast, *hops* and barley. Germinating barley grains, which are called *malt*, contain sugar on which the yeast feeds. Hops are the dried cones of the hop plant. They are put into beer to preserve it and give it flavour.

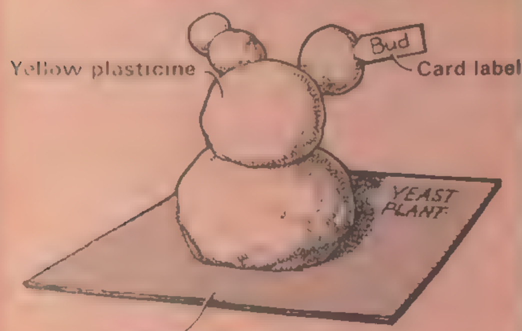
MORE THINGS TO DO

1. Draw a yeast plant. Label a bud.
2. Write one sentence about each of these words in a way which shows that you know what the word means.

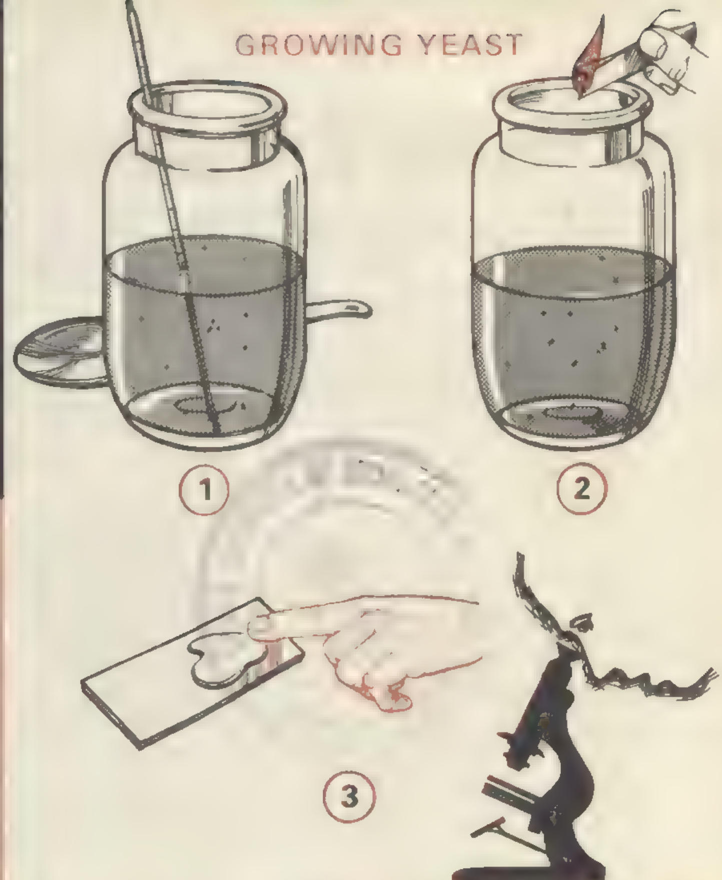
   Yeast; alcohol; intoxication; budding; dough; leavened; unleavened; ferments; wine; hop; malt; beer.
3. Visit a brewery if you get a chance.

Bread and wine

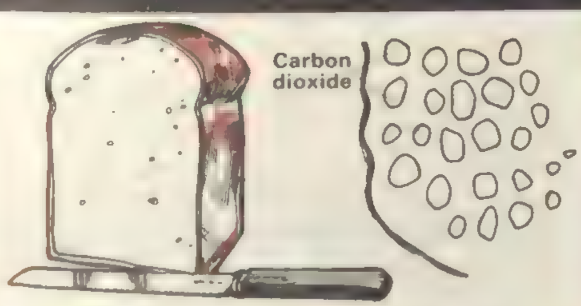
MODEL YEAST PLANT



GROWING YEAST

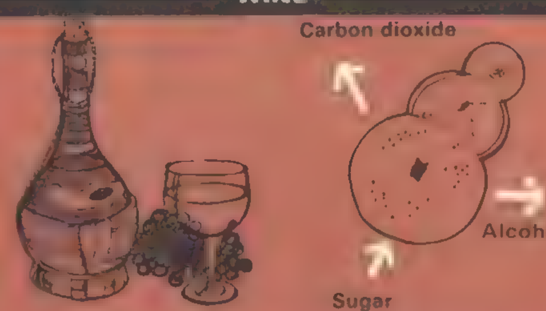


BREAD



The carbon dioxide from yeast makes bread spongy

WINE

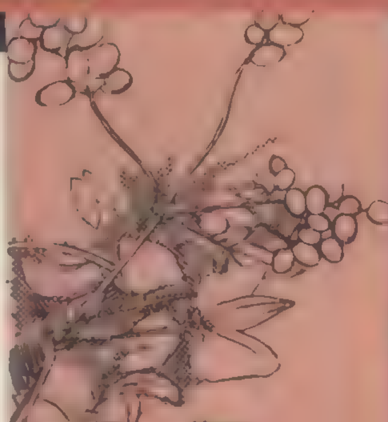


Wine is made from sugar, yeast, water and fruit or vegetables

BEER

Beer is made from yeast,

Barley



Hops

Alcohol causes

36 Fresh food

Food "goes bad"

Milk, fish and meat do not keep fresh for long. They "go bad" very quickly in warm weather.

What causes food to "go bad"? *Bacteria* from the air fall on to the food where they feed and multiply and so cause it to decay. The decaying food is unfit to eat. Bacteria multiply more quickly when they are warm. That is why food "goes bad" quicker in warm weather than it does in cold weather.

Bacteria are very tiny plants that can be seen only under a microscope.

Food poisoning

It is dangerous to eat decaying food because some of the bacteria on it may produce poisons. These poisons can cause illness or even death. Some of the bacteria that cause food poisoning are shown opposite.

It is wrong to think, as some people do, that cooking and *refrigeration* will make decaying food fit to eat. It is true that heat and cold prevent bacteria from multiplying, but heat and cold do not destroy the poisons that the bacteria have already made.

Preserving food

Food can be preserved so that it will not decay and will remain fit to eat for a long time if bacteria are kept away from the food or prevented from multiplying. But, food that is to be preserved must be fresh to begin with. Why?

The various ways in which food is preserved are shown opposite.

Sealed food keeps fresh

Half fill two test-tubes with water. Put a small piece of fish into each tube. Boil the water in the test-tubes. This will kill any bacteria on the fish. Then, seal one of the test-tubes with a cork.

After a week, remove the cork and sniff the contents of the test-tubes. The fish in the tube that was sealed is still fresh. The fish in the unsealed tube has "gone bad". Why?

Dry food keeps fresh

Put a tablespoonful of flour into each of two small jars. Then, half fill one of the jars with water.

After a fortnight, sniff the contents of the jars. There is an unpleasant smell from the jar that contains flour and water. There is no unpleasant smell from the jar that contains dry flour. What does this show?

Pickling

Put a small piece of fish into each of two small jars. In one jar, cover the fish with vinegar.

After a week, sniff the contents of the jars. Which piece of fish has "gone bad"? What has happened?

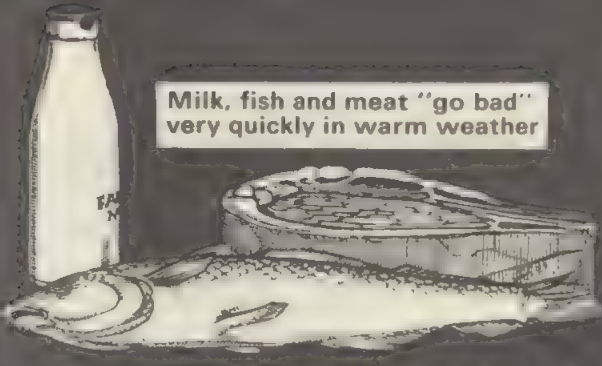
MORE THINGS TO DO

1. Copy the drawings shown in the black frames opposite.
2. Write a few sentences about food poisoning.
3. Copy this sentence.

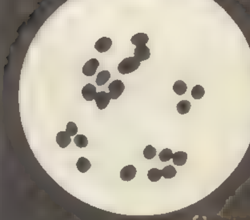
Preserving food

Food is preserved by canning, bottling, sugar, pasteurizing, refrigeration, dehydration, pickling, smoking, chemicals and meat safes.

Fresh food



Milk, fish and meat "go bad" very quickly in warm weather



These bacteria cause food poisoning

PRESERVING FOOD

CANNING

[illegible] is put into [illegible] heated. This [illegible]

BOTTLING

This is the same as canning, but sealed bottles are used instead of cans.

SUGAR

The food is sealed in boiled sugar. Bacteria cannot grow in the sugar.

PASTEURIZING

Milk is heated and cooled very rapidly. This kills any bacteria in the milk. Pasteurizing was introduced by Louis Pasteur, the great French chemist

REFRIGERATION

The food is kept cold in a refrigerator. Bacteria cannot multiply when they are cold

DEHYDRATION

[illegible] iter.

PICKLING

The food is soaked in vinegar. Vinegar is an acid in which bacteria cannot live

SMOKING

This makes a hard layer, poisonous to bacteria, on the outside of the food

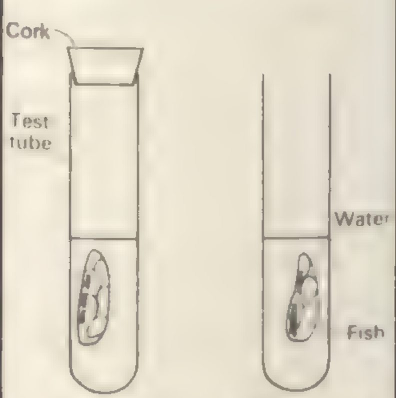
CHEMICALS

Chemicals, which kill bacteria but are harmless to humans, are put into some foods

MEAT SAFES

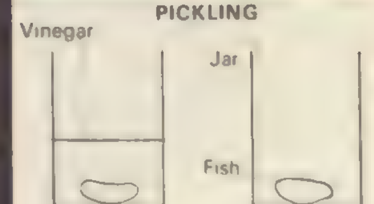
Meat and fish are covered with a fine wire mesh that keeps out flies that carry bacteria. But, bacteria in the air can reach the meat

SEALED FOOD KEEPS FRESH



DRY FOOD KEEPS FRESH

PICKLING



37 The food goes down

Eating

What do you do when you are eating? You chew the food in your mouth, and then, when you swallow, the food goes down into your stomach. But, what happens to the food after it has gone down into your stomach? The food is broken up and changed into simple chemicals which can be taken into your bloodstream. This is called *digestion*.

The alimentary canal

When food enters your mouth, it is at the first stage of a long journey through the *alimentary canal*. "Alimentary canal" means "food tube". The alimentary canal begins at the mouth and ends at the *anus*. A drawing of the human alimentary canal is shown on the page opposite.

Here is a list of the main parts of the alimentary canal and what they do.

The Parts of the Alimentary Canal

Mouth. Teeth grind food into small pieces. This is called *mastication*. The small pieces can be swallowed and acted on more easily by *saliva*. Saliva from the *salivary glands* changes starch into sugar.

Gullet. Wavy movements of rings of muscle pass food from the mouth into the stomach.

Stomach. Churns up the food and holds it for about 3 hours. *Gastric juices* change *proteins* into simple chemicals.

Duodenum. About 30 centimetres in length. *Bile* from the *gall bladder*, which is in the *liver*, *emulsifies* fats and oils.

Small intestine. Thin hair-like growths, called *villi*, take in the digested food and pass it into the bloodstream.

Large intestine. Absorbs water.

Appendix. Useless tube. If this becomes diseased, its owner has *appendicitis*; the appendix must be removed by a surgeon.

Rectum. Rings of muscle pass undigested food and waste out of the alimentary canal.

Anus. Where waste leaves the alimentary canal.

Saliva changes starch into sugar

Half fill a test-tube with water. Drop a little starch into the tube. Shake the test-tube and then add to it a few drops of iodine. The colour of the starch changes from white to blue-black. This is the usual test for starch.

Now, half fill a test-tube with warm water. Drop a little starch powder into the tube. Spit into the tube and then shake it. After a few minutes, add a few drops of iodine. The contents of the test-tube do not become blue-black in colour. This shows that no starch is present. The saliva has changed the starch into sugar.

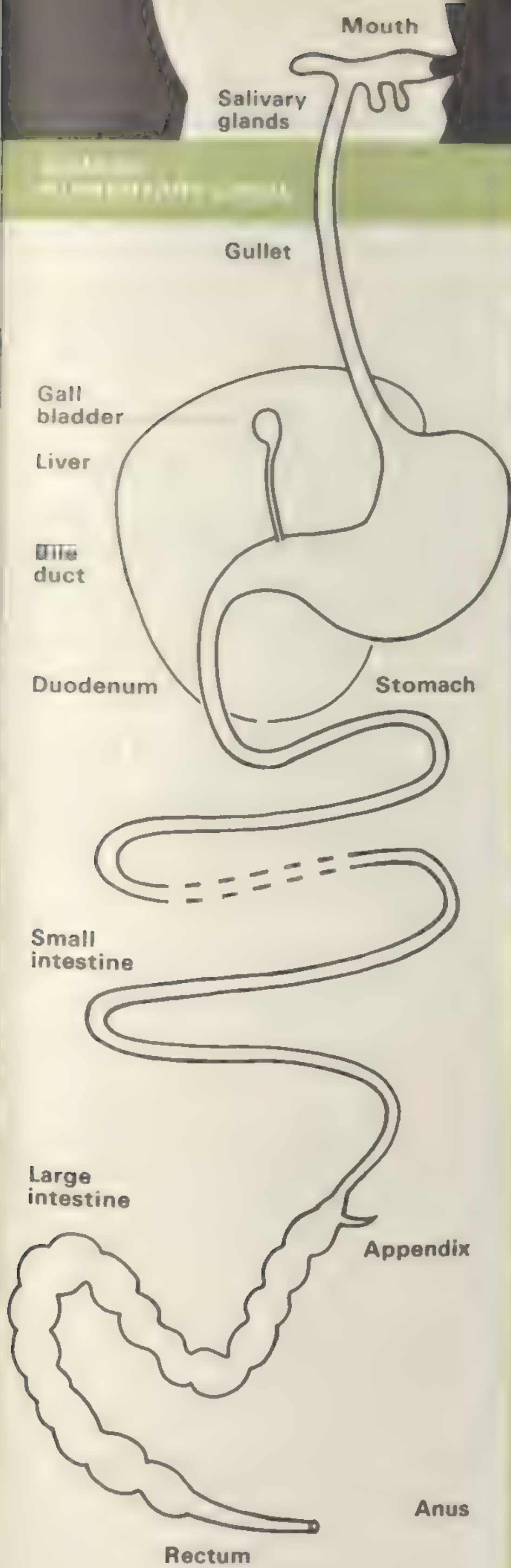
A rat's alimentary canal

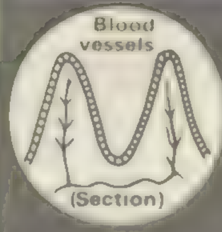
Perhaps your teacher will *dissect* a rat so that you will be able to see the main parts of its alimentary canal. (Teacher: a dissection guide, such as *Guide To Dissection*, by R. G. G. Rowett, M.A., *John Murray*, will be very helpful here.)

MORE THINGS TO DO

1. Use tracing paper to copy the drawing of the human alimentary canal shown opposite. Label each part.
2. Copy the list of the parts of the alimentary canal.

The food goes down





VILLI

RAT'S ALIMENTARY CANAL

Green food rots in the caecum. A human being does not have a caecum.

38 Blood

A precious liquid

Blood is a precious liquid. Your blood helps you to keep alive. If you cut yourself badly, you bleed quickly, and if you lose a lot of blood, you become very weak. If the bleeding is not stopped, you will bleed to death.

What blood does

What does blood do that makes it so precious? Blood does three important jobs. Here they are.

1. *Transport*. Blood carries food and oxygen to the tissues in all parts of the body. Food enters the bloodstream through tiny blood vessels in the small intestine. Oxygen enters the bloodstream through tiny blood vessels in the lungs. Blood also carries waste from the tissues to the *kidneys* and on to the *bladder*. Liquid waste collects in the bladder.

2. *Providing water*. Blood provides the tissues with water. Almost 7/10 of the human body is water.

3. *Fighting disease*. Blood destroys some of the disease-bacteria that enter the body.

What is blood?

Blood contains three things *plasma*, *red corpuscles* and *white corpuscles*.

Plasma is a yellowish, transparent liquid that contains salts, sugar, drops of oil and other chemicals. The liquid in a blister is plasma.

Red corpuscles are disc-shaped and very small. They give blood its red colour, although under a microscope, they are yellow. They carry oxygen around the body.

White corpuscles are colourless and much larger than red corpuscles. Under a microscope, they look like pieces of jelly. They are alive and feed on bacteria in the blood. In this way, white corpuscles fight diseases.

The heart

An adult person has about 9 pints of blood which is *circulated* in tubes throughout his body by the action of his *heart*. "Circulated" means "moved around". The heart is a pump with muscles that work automatically. The tubes that carry blood from the heart are called *arteries*. Those that carry blood to the heart are called *veins*. The very tiny tubes are called *capillaries*.

The circulation of the blood was discovered by Dr. William Harvey who was physician to King Charles I.

The speed at which a heart *beats*, or pumps, is called the *pulse*. The heart beats about 72 times per minute in a healthy person.

A sheep's heart

Perhaps your teacher will show you a sheep's heart. Look for the large arteries and veins on the heart.

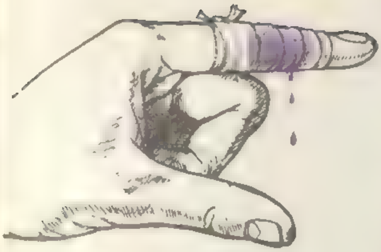
Measuring the pulse

Place the second finger of your right hand on the artery in your left wrist and, looking at a watch, count the number of beats that your heart makes in one minute. What is your pulse?

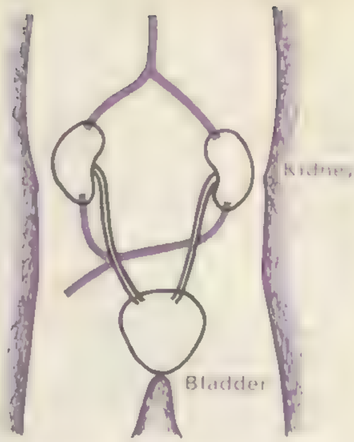
MORE THINGS TO DO

1. Draw a red corpuscle.
2. Draw a white corpuscle.
3. Write a short essay with the title *Blood*.
4. Measure the pulses of your parents and friends. You can do this at home.

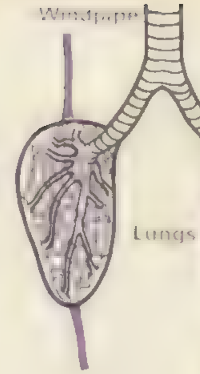
Blood



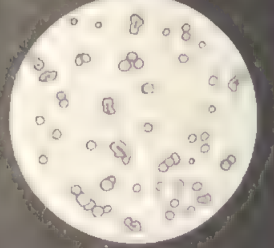
Blood is precious



Blood carries waste to the kidneys

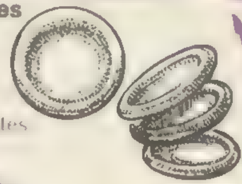


Oxygen enters the bloodstream through capillaries in the lungs



Blood corpuscles as seen under a microscope

Red corpuscles

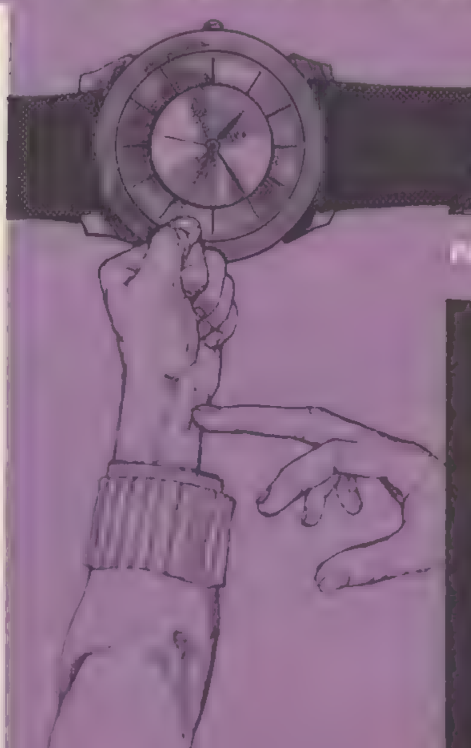


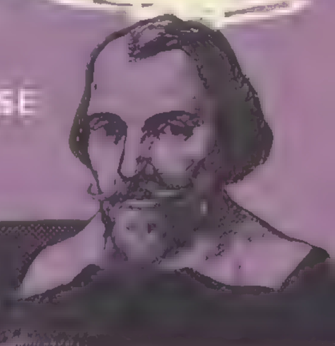
2500 red corpuscles in a row would make a line as long as this

White corpuscles

SHEEP'S HEART

MEASURING THE PULSE





Dr. William Harvey
Physician to King Charles I

BLOOD CAPILLARIES

39 Die Fledermaus

The bat: an unusual mammal

The bat is a most unusual mammal because it can fly. In fact, it is the only mammal that can fly. But, though the bat can fly like a bird, its wings are not like the wings of a bird. The bat's wings are not made of feathers. They are large flaps of thin skin that are stretched between its very long fingers.

In Germany, the bat is called *Die Fledermaus*. "Die Fledermaus" means the "flitter-mouse". This is a very good name for the bat because it does flit about and its body is small and furry like that of a mouse.

A mother bat gives birth to one baby at a time. A baby bat is tiny, naked and blind, but its wings are quite strong. It is carried about by its mother for the first 14 days of its life.

The bat hibernates during the winter.

Bats and superstitions

Bats flit silently and at night. They seem to be sinister creatures. For that reason, there are many superstitions about bats. In some parts of the world, it is believed that bats are the souls of people who are either asleep or dead. Years ago, alchemists and witches used bats in their experiments and magic.

Some people believe that bats live on human blood. But, really, most bats are quite harmless. There are thousands of different kinds of bats in the world, and nearly all of them feed on fruit or insects. The *flying fox*, which has a wing span of nearly two metres, is a fruit-eating bat. However, there are a few bats, the so-called *vampire bats*, that feed on blood which they drain from birds and other animals.

Bats "hear their way"

If a person has poor sight, we say that he is "as blind as a bat". But, these are the wrong words to use because most bats are not blind. They can see very well in daylight.

Bats are active at night. They cannot see in darkness, but they can "hear their way" by echoes. A bat makes high-pitched cries which we are unable to hear because they are above the human hearing range. The sounds of the cries strike objects and are reflected back into the large trumpet-shaped ears of the bat. In this way, the bat finds out where the objects are and it can fly so as to avoid them.

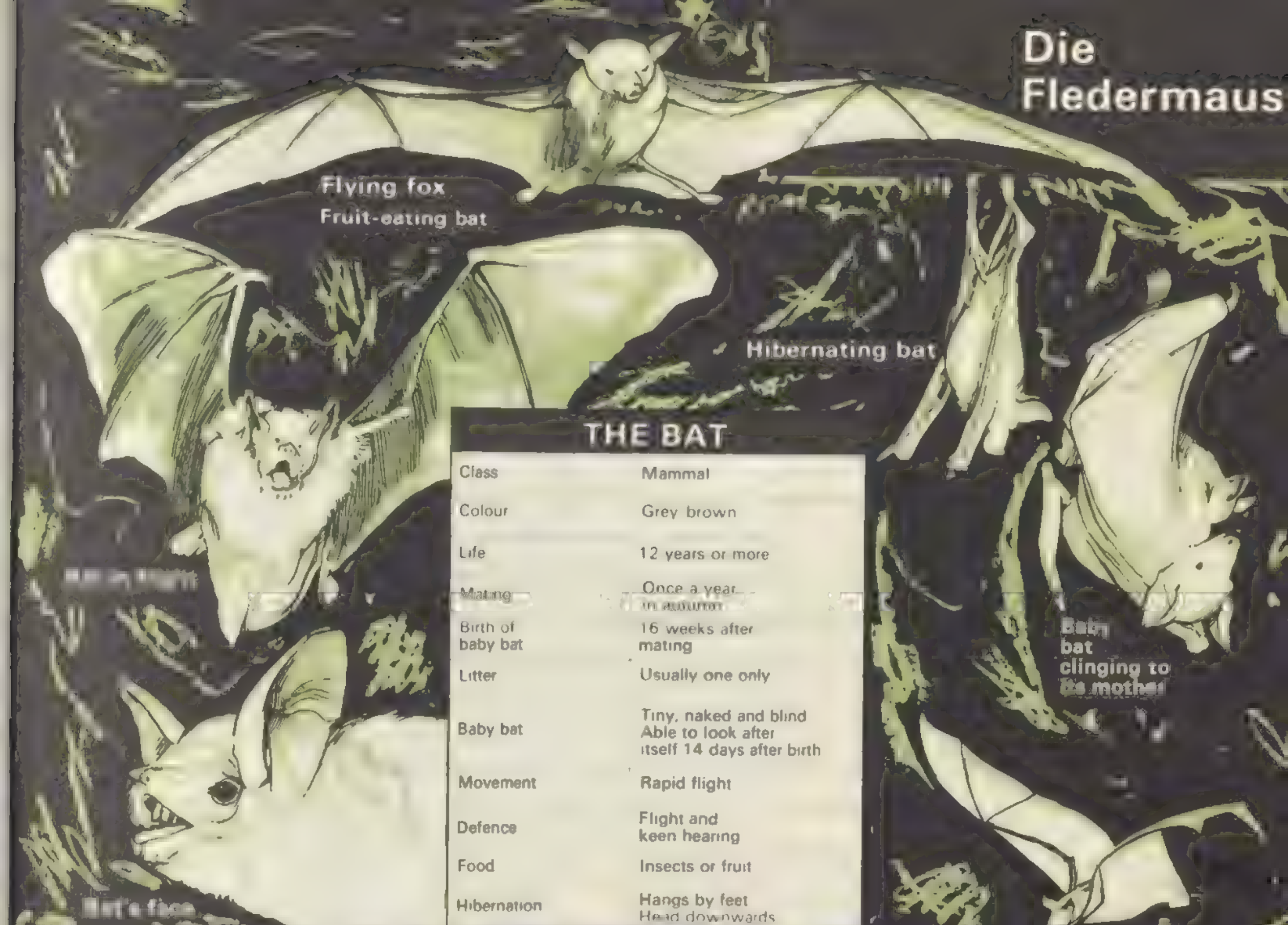
Other unusual mammals

The bat is an unusual mammal because it can fly. Some other unusual mammals are shown on the page opposite.

MORE THINGS TO DO

1. Draw a hibernating bat. An easy way to do this is shown opposite. Colour the drawing brown or purple.
2. Copy the drawing shown in the black frame opposite.
3. Copy "THE BAT" table shown opposite.
4. Make a list of unusual mammals.

Die Fledermaus



THE BAT

Class	Mammal
Colour	Grey brown
Life	12 years or more
Mating	Once a year in autumn
Birth of baby bat	16 weeks after mating
Litter	Usually one only
Baby bat	Tiny, naked and blind. Able to look after itself 14 days after birth
Movement	Rapid flight
Defence	Flight and keen hearing
Food	Insects or fruit
Hibernation	Hangs by feet Head downwards

BATS "HEAR THEIR WAY"

Shrill cries are reflected by objects into the large trumpet-shaped ears.

SOME UNUSUAL MAMMALS

Whale

Warm-blooded. Babies are called calves. Swims in the sea

Duck-billed platypus

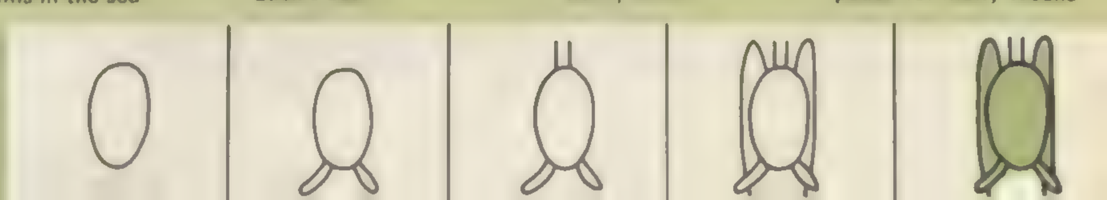
Lays eggs. Mouth is like a duck's beak

Pangolin

Covered with armour of horny scales

Koala bear

Baby lives in its mother's pouch for many weeks



40 Living things

"Animal, vegetable or mineral"?

Have you ever played the "animal, vegetable or mineral" game? In this game, you are expected to look at an object and then decide whether it is animal, vegetable or mineral. But, some mineral objects are also animal or vegetable, and so the game can be rather confusing. A lump of coal, for example, is mineral because it is got out of the earth by mining; it is also vegetable because it is made from compressed plants. Look at the things displayed on the table shown opposite. Which are animal? Which are vegetable?

Dead or alive?

Now, look at the things again. Which are alive? Which are dead? Which have never been alive? Be careful because some of the things that are alive appear to be dead. Twigs and bulbs are alive.

A ventriloquist's doll

A ventriloquist's doll has legs, arms, eyes, ears, a mouth and a nose, but it is not alive. Its "voice" is really the voice of a ventriloquist.

You can smell, touch, taste, hear, see, eat, breathe, move and think. A ventriloquist's doll can do none of these things. But then, you are made of living flesh, whereas the ventriloquist's doll is made of wood or plastic.

Living things

Plants cannot smell, taste, hear and see. They cannot move as quickly as animals move. But, plants are alive.

All living things, whether plant or animal, can *move, feed, grow, breathe* and *reproduce.*

Plants do not travel from place to place, but they do move. Some flowers open slowly in the morning and close slowly in the evening.

Plants feed, through their roots, on the mineral salts in soil, water and, through their leaves, on the carbon dioxide in the atmosphere.

Plants breathe through the tiny breathing holes on their leaves.

Reproduction

What is so remarkable about living things is that they can reproduce themselves. Plants make seeds which grow into new plants. Animals make eggs which grow into new animals. Things that are not alive cannot reproduce themselves. Rabbits have baby rabbits, but buckets do not have baby buckets!

Growth

Icicles and crystals grow but their growth is not a living growth. They grow in layers.

Growing a crystal

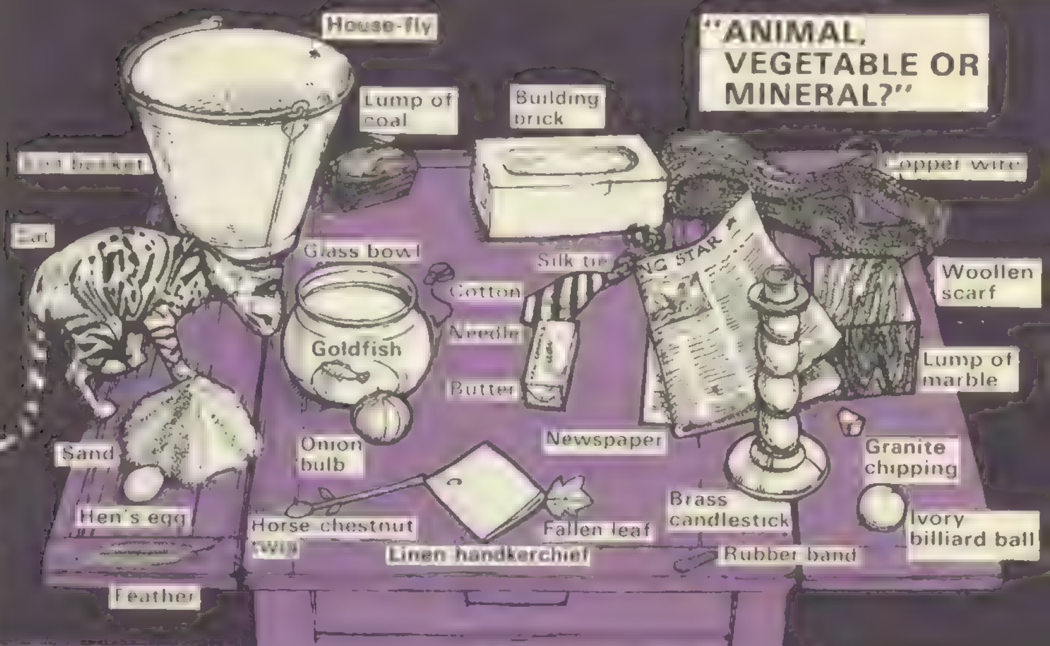
Grow a copper sulphate crystal in the way shown opposite. Is the crystal alive?

MORE THINGS TO DO

1. Draw a teddy bear. An easy way to do this is shown opposite. Colour the drawing.
2. Write a few sentences to explain why a teddy bear is not alive.
3. Copy the drawing shown in the black frame opposite.
4. Copy these sentences.

Living Things

Living things move, feed, grow, breathe and reproduce. Things that are not alive cannot reproduce themselves.



Living things

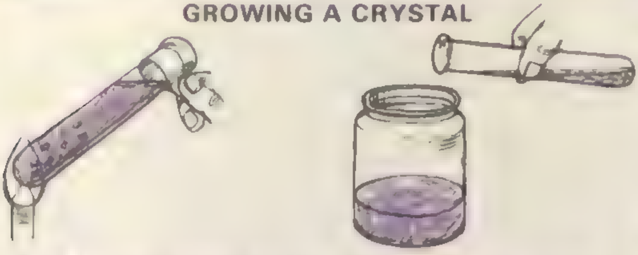

VENTRILOQUIST'S DOLL

ICICLE

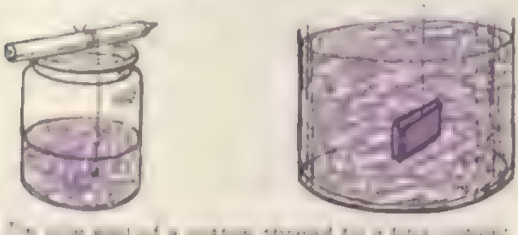

An icicle is not alive. It grows in layers

REPRODUCTION

GROWING A CRYSTAL

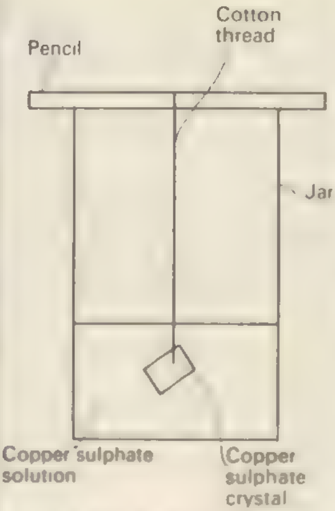


1 Put much copper sulphate in water in a test tube. Boil the water until all the copper sulphate has dissolved.
2 Allow the copper sulphate solution to cool. Then pour it into a small jar.



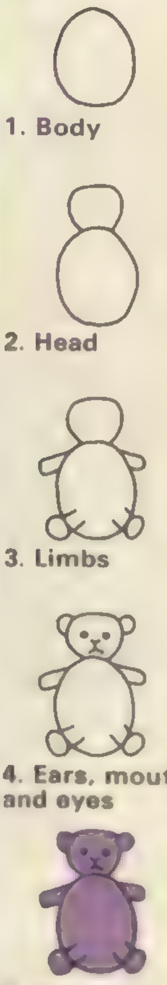
3 [illegible]
4 [illegible]

GROWING A CRYSTAL



A simple drawing for your notebook

DRAWING A TEDDY BEAR



41 Crystals

How a crystal grows

In the previous chapter, you grew a large crystal of copper sulphate. This is how the crystal grew. The water in the copper sulphate solution evaporated slowly until some of the copper sulphate could no longer remain in the solution. This copper sulphate formed a layer on the inside of the jar and around the tiny crystal hanging in the solution. After a time, the tiny crystal became a large crystal made up of many layers of copper sulphate.

Crystals

Some substances, like sugar and copper sulphate, will form definite shapes that are called *crystals*. All the crystals of the same substance have the same shape. For example, table salt crystals are cube-shaped and *alum* crystals are double pyramids. The crystals of some common substances are shown opposite.

Do not make the mistake of thinking that glass is crystalline. A piece of glass can be moulded into almost any shape. If a piece of glass is broken up, none of the smaller pieces have the same shape.

Growing crystals

Grow large crystals of *barley sugar*, *washing soda* and *alum* (*teacher*: use potash *alum*) in the same way that you grew a copper sulphate crystal.

Making a crystal star

Bend a length of copper wire into the shape of a star. Use cotton-covered wire because crystals grow more easily on a rough surface. Tie one end of a cotton thread to the star. Tie the other end to a pencil. Place the pencil across the top of a jar of alum solution so that the star hangs in the solution.

After a few days, look at the star. What do you notice?

Making a crystal "garden"

Place some clean sand on the bottom of a large glass jar. Fill the jar with a *water-glass* solution. Use one part of water-glass and three parts of water. Perhaps your teacher will help you with this. Drop a few crystals of *potassium dichromate* into the jar. These will colour the solution green. Now, drop a few crystals of the following substances into the jar.

Copper sulphate; "*hypo*"; *iron sulphate*; potash alum; *chrome alum*; Epsom salt (*magnesium sulphate*); cobalt chloride.

The crystals dissolve slowly. They do not dissolve quickly as they would do in ordinary water. After a few days, you will have a crystal "garden".

Stalactites and stalagmites

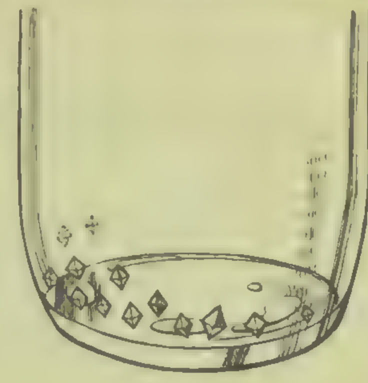
Some caves contain long pillars of rock. Those that descend from the roof of a cave are called *stalactites*; those that ascend from the floor are called *stalagmites*. They are made of tiny crystals of *limestone* which, during a long period of time, have been slowly left behind by dripping water that has a little *calcium carbonate* dissolved in it.

MORE THINGS TO DO

1. Draw some of the crystals shown opposite. Print their names below them.
2. Draw a crystal star.
3. Use an encyclopedia to find out what you can about *stalactites* and *stalagmites*.

Crystals

GROWING CRYSTALS



MAKING A CRYSTAL GARDEN

SOME COMMON CRYSTALS

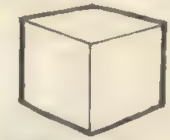
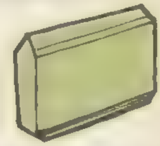
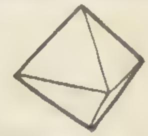


Table salt

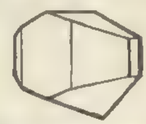


Copper sulphate



Alum

Washing soda



Glauber's salt

42 Density

A catch question

Which weighs more – a kilogramme of lead or a kilogramme of feathers? You may be tempted to say that the lead weighs more; after all, we do say "as heavy as lead" and "as light as a feather". But, the question is a catch. The lead and the feathers weigh the same. Obviously, a kilogramme of lead must weigh the same as a kilogramme of feathers.

However, a kilogramme of lead occupies much less space than does a kilogramme of feathers. A kilogramme of lead is smaller than an egg; a kilogramme of feathers would fill a large bag. This is because the lead is much *denser* than the feathers.

Density

A log of wood is much heavier than an iron nail, and so what do we mean when we say "iron is heavier than wood"? We mean that iron weighs more than wood if they occupy the same amount of space. A cube of iron is heavier than a cube of wood if both cubes are the same size. Really, we should say, "iron is denser than wood" or "the *density* of iron is greater than the density of wood".

Which weighs more – a bucket full of iron filings or a bucket full of feathers?

The density of water is 1 kilogramme per litre. This means that a litre of water weighs 1 kilogramme. The density of petrol is 0·7 kilogrammes per litre. The density of mercury is about 13·6 kilogrammes per litre. Which is denser – mercury or petrol?

Relative density

The *relative density* of a material is the number of times that it is denser than water. A litre of water weighs 1 kg and a litre of mercury weighs 13·6 kg; the mercury is 13·6 times heavier than the water. 13·6 is the relative density of mercury. The relative density of water is 1. Why?

The relative densities of some common materials are shown opposite.

Finding relative densities

Hang a small plastic bucket on the hook of a spring balance. What is the weight of the bucket?

Fill the bucket with water. What is the weight of the bucket of water?

Take the weight of the bucket away from the weight of the bucket and water together. This will give you the weight of the water.

Then, fill the bucket, in turn, with each of the following materials and find their weights as you did with the water.

Methylated spirit; sawdust; sand; sea-water; paraffin; sugar; table salt.

Now, work out the relative densities of the materials.

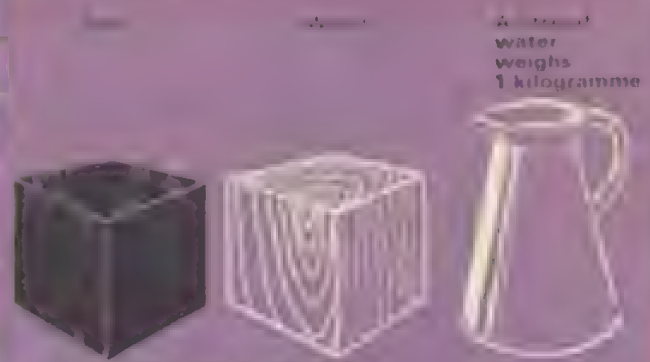
Relative density of material = weight of material ÷ weight of water.

MORE THINGS TO DO

1. Write a few sentences to explain what is meant by *density* and *relative density*.

2. Do the simple problems on density that are shown opposite.

Which weighs more — a kilogramme of lead or a kilogramme of feathers?

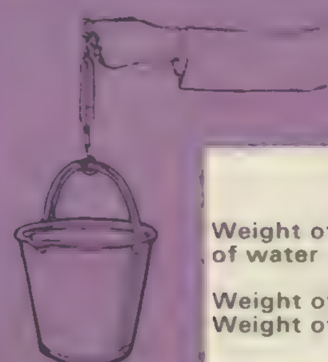


Density

SOME RELATIVE DENSITIES

Water	1·0	Ice	0·85
Gold	19·3	Milk	1·03
Mercury	13·6	Sea-water	1·03
Copper	8·9	Olive oil	0·9
Iron	7·8	Marble	[illegible]
Silver	10·5	Petrol	0·7
Lead	11·3	Alcohol	0·8
Zinc	7·2	Cork	0·25
Aluminium	2·7	Wood	0·5 to 0·9

FINDING RELATIVE DENSITIES



A simple sum

Weight of bucket of water =

Weight of bucket =

Weight of water =

SOME SIMPLE PROBLEMS ON DENSITY

1. What is the density of petrol, in kg per litre, if 3 litres of petrol weigh 2·1 kg?

2. An empty bucket weighs 1 kg. Full of water, it weighs 11 kg, and, full of turpentine, it weighs 9·7 kg. What is the relative density of turpentine?

3. Two cubes, one of iron and one of gold, are both the same size. The iron cube weighs 7·8 kg. What is the weight of the gold cube?

4. What is the weight of 4 litres of water?

5. What is the weight of 1 litre of olive oil?

43 Common salt

Salt for health

Do you like plenty of salt on your food? Salt is put into your food to give it flavour and to help you to keep healthy. Your blood contains salt which is lost when you perspire; the salt that is lost must be replaced.

All animals need salt. When a dog licks your hand, you think that he is being friendly, but he may only be after the salt in your perspiration.

Common salt

The salt that is put into food is called *common salt* or *table salt* so that it is not mistaken for some other kind of salt, such as *Epsom salt* or *Glauber's salt*.

Do not think that all salts are harmless and good to eat. Copper sulphate is a salt; it is poisonous.

Chemists have another name for common salt; they call it *sodium chloride*.

Sodium chloride is white and crystalline. It dissolves very easily in water. Sodium chloride solution is called *brine*.

Where common salt is found

Common salt is found in the ground and in sea-water.

The common salt in the ground is called *rock salt*. It is obtained by mining or by spraying the salt with water and then pumping the brine to the surface where the water evaporates and the salt is left behind.

The common salt in sea-water is called *sea-salt*. Nearly 3% of sea-water is common salt. This salt is obtained by pumping sea-water into shallow pans where the water evaporates and the salt is left behind.

Growing salt crystals

Stir some common salt in a jar of water until no more will dissolve. Pour the liquid into a saucer.

After a week or more, examine the salt crystals in the saucer. What has happened to the water?

Looking at salt crystals

Place a few of the salt crystals on a microscope slide and look at them under a microscope (use the low-power). Perhaps your teacher will help you with this. What is the shape of a common salt crystal?

The salt in sea-water

Put a little sea-water in a clean test-tube and heat it until all the water has boiled away. Notice the white film of salt around the inside of the tube.

When the test-tube is cool, shake it so that the salt falls on to a sheet of paper. Taste the salt. Does it taste like common salt?

The density of sea-water

Sea-water is slightly denser than pure water. That is why swimmers can keep afloat more easily in sea-water than they can in fresh water.

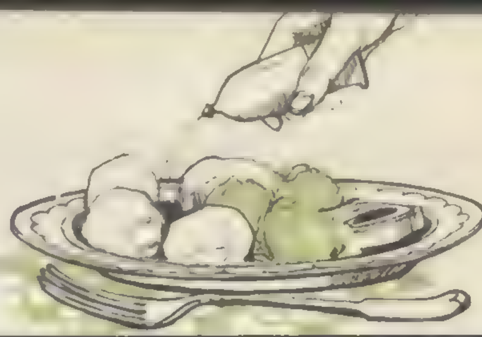
MORE THINGS TO DO

1. Write one sentence about each of these things.

Sodium chloride; brine; copper sulphate; rock salt; sea-salt.

2. Work out the weight of 10 litres of sea-water. A litre of fresh water weighs 1 kilogramme. The relative density of sea-water is 1·03.

SALT FOR HEALTH



Common salt

2·8% of sea-water is salt

GROWING SALT CRYSTALS

THE DENSITY OF SEA-WATER

The relative density of sea-water is 1·03

44 Life on the sea-shore

A walk on the sea-shore

There is much interesting plant and animal life on the seashore. Some sea-shore plants and animals are shown on the page opposite. They are but a few of the many plants and animals that are to be found on the shores of Britain.

The next time you go to the seaside, take a walk along the sea-shore and look for some of these plants and animals.

Among the sand and pebbles, you will find *lug worms, peacock worms, sand mason worms* and *sand-hoppers*. These creatures live in the sand.

You will also find seaweeds, small crabs, mollusc shells, *starfishes, jelly-fishes* and "mermaids' purses". These things really belong to the sea, but they are washed up on to the beach by the tides. "Mermaids' purses" are the egg-cases of big fishes, like the skate and the dogfish.

In the rock pools and shallow waters, you will find *mussels, limpets, whelks, winkles, barnacles, shrimps, sea anemones, hermit crabs* and small fishes, like the *pipefish, butterfish, blenny* and *goby*. You may find the odd *flatfish*.

Two unusual sea-shore animals are the sea anemone and the hermit crab. The former has a plant-like name and looks like a flower when its tentacles are open. The latter has no shell of its own to protect the soft parts of its body and so makes its home in an empty whelk shell.

Most of the plants on the sea-shore are seaweeds. Seaweeds do not have flowers, roots and real leaves. Two common seaweeds are the *bladder wrack* and the *thong weed*. But, there are a few flowering plants on the sea-shore. Two of these are *marram grass* and *sea holly*.

The *sea-cucumber* is not a plant. It is a very simple animal that is closely related to the *sea-urchins* and starfishes.

Now, look carefully at the sea-shore animals shown opposite. Which are molluscs? Which are true fishes?

Collecting sea animals

If you live near the seaside or when you visit the seaside, collect some sea-shore animals. Keep the different kinds of water animals in separate jars of sea-water. Bring the animals to school. Your teacher and your class-mates will help you to find out their names.

A sea-water aquarium

Make a sea-water aquarium in the way shown opposite.

Sea animals need plenty of air. If you do not have an electrically operated *aerator*, you can aerate the aquarium with an old bunsen burner in the way shown opposite.

Do not keep the animals for more than a few days; then, you will have no feeding problems.

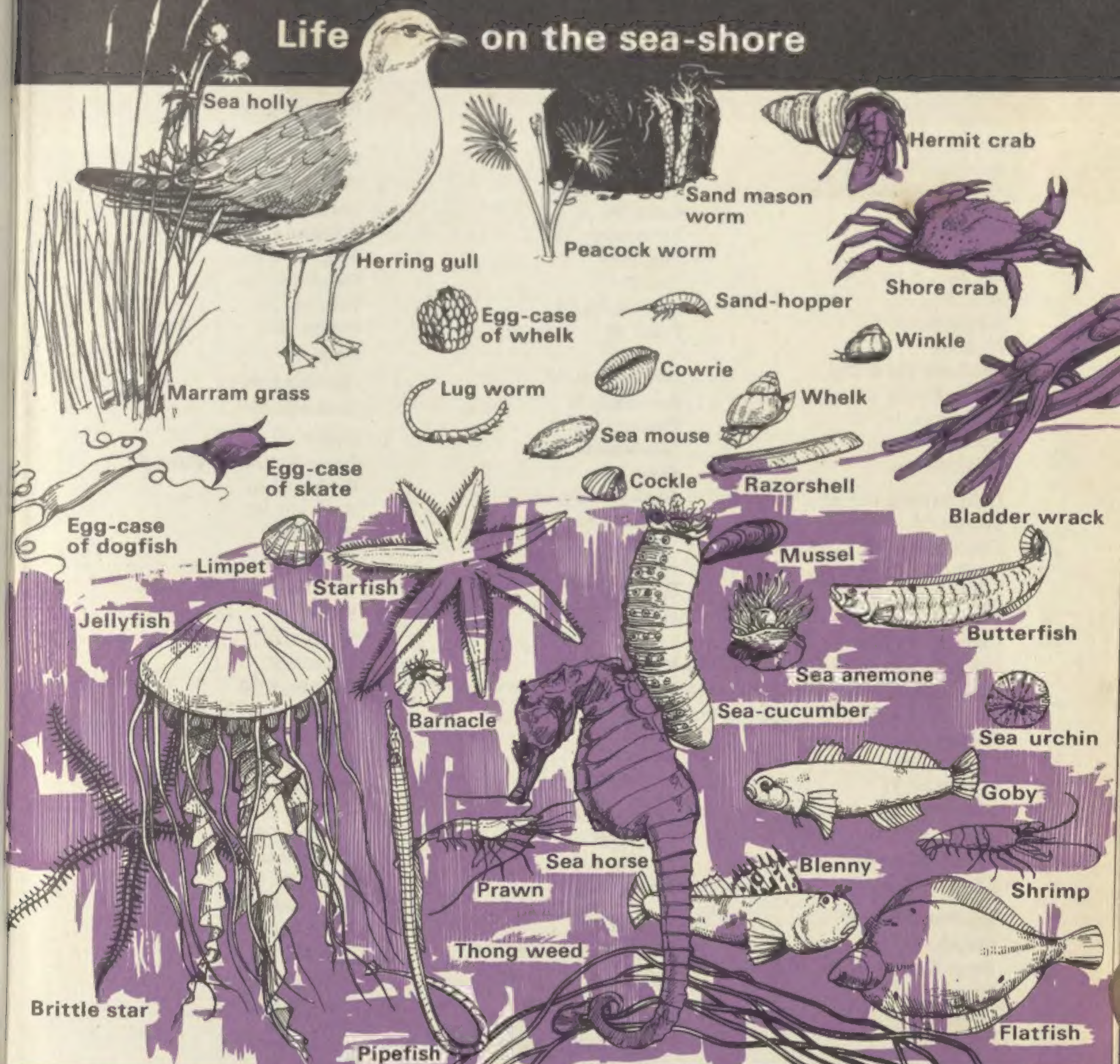
MORE THINGS TO DO

1. Make free-hand drawings of some of the sea-shore plants and animals shown opposite. Print their names below them.

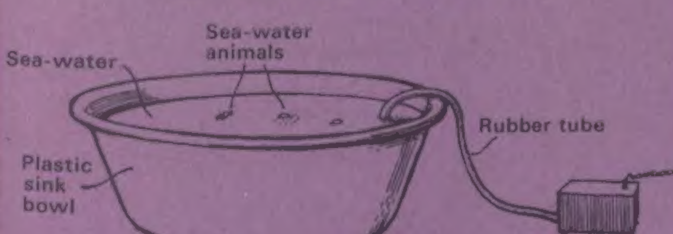
2. Write one sentence about each of these things.

"Mermaids' purse"; sea anemone; hermit crab; sea-cucumber; marram grass.

Life on the sea-shore

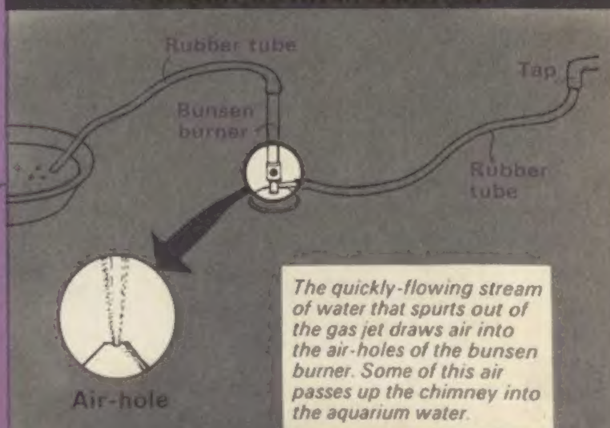


SEA-WATER AQUARIUM



Suitable animals:
shrimp; prawn; mussel; cockle; winkle; sea anemone; starfish; shore crab; hermit crab; whelk; blenny.

BUNSEN BURNER AERATOR



The quickly-flowing stream of water that spurts out of the gas jet draws air into the air-holes of the bunsen burner. Some of this air passes up the chimney into the aquarium water.

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